REPORT RESUMES

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OCCASIONAL PAPERS ON PROGRAMED INSTRUCTION, I. PROGRAMED INSTRUCTION IN OTHER COUNTRIES.
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REPORTS WERE PRESENTED ON THE DEVELOPMENT AND STATE-OF-THE-ART OF PROGRAMED INSTRUCTION IN THE UNITED KINGDOM, JAPAN, FRANCE, AND THE SOVIET UNION. KENNETH AUSTWICK, UNIVERSITY OF SHEFFIELD, HIGHLIGHTS THE PICTURE IN THE UNITED KINGDOM WHERE INTEREST HAS GROWN RAPIDLY SINCE 1961. THE AUTHOR POINTS OUT THAT PERHAPS THE MOST EXCITING WORK IS BEING DONE BY GORDON PASK IN THE UNITED KINGDOM, WHO IS DEVELOPING EXTRINSICALLY ADAPTIVE TEACHING MACHINES. MITOJI NISHIMOTO, DIRECTOR OF THE AUDIOVISUAL CENTER, INTERNATIONAL CHRISTIAN UNIVERSITY, REPORTS ON DEVELOPMENTS IN JAPAN, WHERE A BRIGHT FUTURE FOR TEACHING MACHINES AND PROGRAMED LEARNING IS PREDICTED. GEORGE DECOTE, BROOKLYN COLLEGE, NEW YORK, REVIEWS THE STATUS OF PROGRAMED INSTRUCTION IN FRANCE. PERSONNEL AND ORGANIZATIONS ACTIVE IN THE FIELD ARE DISCUSSED. DEVELOPMENTS IN THE SOVIET UNION ARE PRESENTED BY HARMAT VOGT, UNIVERSITY OF MARBURG. PARTICULAR ATTENTION IS DEVOTED TO CYBERNETICS IN THEORY AND PRACTICE IN SOVIET EDUCATION. NUMEROUS DEVELOPMENTS ARE REPORTED. (JC)

STANFORD *Institute for Communication Research*

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OCCASIONAL PAPERS ON PROGRAMMED INSTRUCTION

I. Programmed Instruction in Other Countries

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UK WORK ON TEACHING MACHINES AND PROGRAMMING

by

Kenneth Austwick
University of Sheffield

Interest in the field of teaching machines and programmed learning has grown rapidly in the United Kingdom since 1961. Prior to this, of course, a great deal of pioneering work had already been done by Gordon Pask in the field of adaptive machines; this was known in Britain and the United States but the topic had not yet caught the public eye.

Probably the first occasion on which popular attention was focussed on teaching machines was at the annual meeting of the British Association for the Advancement of Science in Norwich in September 1961. A symposium was held to which Gordon Pask, John Annett, Leslie Reid, and Kenneth Austwick contributed, under the chairmanship of Harry Kay.

Already at that time, Professor Kay, of the Department of Psychology in the University of Sheffield, was leading a research group in the study of industrial applications of teaching machines and programmed learning. Programmes on statistics, income tax, production drawing, logarithms, and other topics have been drawn up by members of the research team -- John Annett, Max Sime, Peter Warr, and later James Hartley and Chris Napper.

The research unit has cooperated with several industrial concerns in devising programmes for training schemes, and a further research grant has recently been awarded to the Department for work in this and other fields of communication. In addition a number of machines have been and are being developed by members of the team. Perhaps the best known is a machine for use with skip-branching constructed response programmes. This is illustrated in Figure 1. The programme is on 35mm film strip and appears on the screen on the left. The information and question, or task, appear on the upper part of the screen and the student writes his answer or response on a plain white card which he then "posts" behind the window on the right. This action operates a photoelectric cell which causes the lower half of the screen to light up displaying the correct response. The card is no longer accessible to the student although he can still read it, i.e., the machine is "cheat-proof." The correct answer is then displayed alongside the student's own response and he is able to assess the latter. If he deems it correct, he presses the lower of the two keys on the right (marked "correct"), his card drops through into the interior of the machine and is sorted, and the next step in the programme appears in the upper half of the screen on the left. If he decides his answer is incorrect, or if he is in doubt, then he presses the upper key, marked "query" -- indicating a need for further help. His card is then "sorted" in the machine, and he is taken along a sub-sequence of frames which break up the step causing difficulty into smaller items.

Thus the programme consists initially of a sequence of main frames (called A-frames) which represent the steps which could be taken by the more able members of the target population. Between each pair of A-frames comes a sub-sequence (of B-frames) in which the content of the preceding A-frame is broken into smaller steps. Thus the programme adapts to individual differences in the sense that an error or failure is taken to imply that the relevant step was too large or too difficult. For simplicity of machine design, a student must follow through a complete B-sequence once he has started on it: in addition, an error on a B-sequence is followed by a re-presentation of the B-frame -- on the assumption that the B steps are so small that errors on them are likely to be due to misreading rather than misunderstanding.

Dr. Annett issued two bulletins -- in June 1961 and in January 1962 -- giving accounts of current work on teaching machines in the United Kingdom. He has now taken up an appointment in the University of Aberdeen. This Scottish university was the centre of the second government-sponsored research unit for teaching machine work. It was directed by Leslie Reid who studied for a time at Harvard, and is now Professor of Psychology in the University of Exeter. He and his colleagues at Aberdeen -- Rex Mitchell, Joan Taylor, and student, Bernard Dodd -- have drawn up and tested programmes on elementary school arithmetic, on chemistry for undergraduates, on training for sales operatives in a London multiple store, and for apprentices in the paper-making industry. Results of the testing of the programme on fractions suggest that the social and economic backgrounds of the children may affect their attitude towards, and hence the effectiveness of, programmes. Several small machines for use in school have been devised and produced in Aberdeen. One of these -- for use with linear-constructed response programmes -- is illustrated in Figure 2. The programme is written on fan-folded paper and appears on the left, the answer being hidden behind the black square on the window. Answers are written on the paper roll on the right and move up behind a window as the correct answer is wound into view -- thus preventing "cheating." The programme and answers are on separate papers, hence the programme may be used again -- i.e., it is "nonexpendable."

After graduating in psychology and taking a considerable part in the construction of the programme for the paper-making industry, Bernard Dodd moved from Aberdeen to the Education Department of Sheffield University where a third research centre -- with government support -- was established in October 1962. This unit is directed by Kenneth Austwick assisted by Dodd and Miss Lewis-White. It is supported by a grant from the Ministry of Education and had, initially, three functions. First was to write programmes suitable for use in secondary school mathematics -- for children of eleven to sixteen years of age; second, to provide lectures, conferences and workshops for teachers and lecturers; and third, to do research into programmed learning and its applications in school and elsewhere. Mathematics programmes have already been tested successfully in English schools -- a preliminary report appeared in Research in November 1962. An investigation into the relative merits of programmed instruction and student note-making was carried out by the writer and a colleague, Pamela K. Poppleton, using samples of University graduates and secondary school children. The results of this study will be published shortly. In addition to programme writing, members of the Unit have given over fifty lectures and organised several conferences and workshops in the United Kingdom during the past twelve months. It is planned to issue a journal during the autumn of this year, 1963, from the Education Department, reporting work from various parts of the United Kingdom. The activities of the Unit are now (1963) being extended, with help from the British Council, to study the applications of programmed learning and language laboratories in the teaching of English as a second language -- particularly in developing countries in the Commonwealth and elsewhere. Naturally this is a matter of considerable interest to Britain in view of her long association with the Commonwealth countries.

Similar problems, concerned with the training of servicemen from Commonwealth and other overseas territories, have led the Royal Air Force to study the possible uses of teaching machines, programmed learning, and other devices in their training schemes. Experiments with the U. S. Industries "Autotutor" have already been reported by the R.A.F. and the Royal Navy. In these, experimental groups working with a programme on trigonometry were as successful as control groups working under normal lecture conditions and took between one-third and one-half the control group times. Further experiments are reported by Michael Knight to be under way in the R.A.F. Technical Training Command. These involve the use of a commercially available programme on basic electronics on the Autotutor. A team at the R.A.F. School of Education at Uxbridge, Middlesex, under the direction of Group Captain Sims, has now developed its own machine -- the Empirical Tutor -- which is being manufactured by Lamson Technical Products (see Figure 4). Perhaps its most interesting feature is the versatility of its display system. Not only can the programme (but not the answer roll!) be reversed, but it can draw upon several ancillaries in the form of tapes, slides, film projectors, oscilloscopes, etc. which provide additional audial and visual display material that can be coordinated with the frames of the programme.

Another British machine which has a flexible display system is the Clements machine (see Figure 5) which was developed for use in the steel industry. A multiple-choice machine for use with Crowder-type programmes -- the Grundytutor (see Figure 6) is now being used in several investigations in schools. The American Autotutor has been available for a longer period than most machines in the British market, and programmes for it on English school mathematics for the General Certificate of Education are already well under way.

A number of local education authorities are conducting or encouraging experiments in their schools and technical colleges and several teachers have designed their own machine.

A multiple-choice device for use with retarded children is illustrated in Figure 7. This was designed by Peter Chapman of Kent, and newer versions of it are being used in the Child Guidance Clinic in Huddersfield, Yorkshire. The machine has been used by Peter Chapman for retarded secondary school children in English and reading exercises and in simple arithmetic. Other linear multiple-choice and constructed-response devices have recently been reported by N. Youd and P. Moss respectively, for use with emotionally disturbed children. Discussions are in progress between the writer and a group concerned with the probation service in London for an experiment into the use of teaching machines with teen-age delinquents. Many of these young offenders appear before courts as a result of anti-social behaviour which may well be the result of continued failure in school and at work. In a sense they may well be regarded as another class of handicapped children for whom the teaching machine may offer some form of help.

A new machine -- the Tutorpack (see Figure 8) -- for use with linear constructed-response programmes is to be tested later this year. Another machine -- the Esatutor (see Figure 9) -- has been developed from prototypes designed by John Leedham, a Junior School headmaster in Leicestershire who has experimented with programmed material for children below the age of eleven. American programmes in algebra and English were tried first and, in view of their success, John Leedham went ahead with plans to prepare his own material. In a report at the end of 1962, he refers to programmes, 1500 frames in all, on punctuation, vocabulary, spelling, and sentence formation.

Another group concerned with the use of American programmes in English schools and colleges is Encyclopedia Brittanica. This company has brought its TEMAC programmes to England and is carrying out experiments, in conjunction with several University departments of psychology and education, to test their material in order to determine whether

(a) it can be used without modification
(b) it needs to be "Anglicised"
(c) it needs to be completely recast for the British market.

As yet the number of published programmes written by English people for use in English schools is very small. A constructed-response programme in geography -- by Patrick Thornhill -- was published some months ago, and a number of mathematics programmes are to be published shortly by Methuens.

In addition to American programmes, several American machines are now available in the United Kingdom. Many of these, the Min/Max, Ferster Tutor, MAST, Didak K007, Graflex Microaid, and others are available through an agency known as Inadcon.

Thus a great deal of preliminary work is going on in English schools. The writing of programmes is itself a useful exercise for teachers and perhaps even more so for teachers in training. Work on programming is being introduced into teacher training colleges (for nongraduate teachers) and in institutes and departments of education in the universities. Experimental work has already been reported from Birmingham, and graduate teachers in training (including visiting American students!) can include a course on teaching machines at Sheffield University. Also in the field of further education, experiments are in progress in colleges of technology. A new research project is getting under way at Brighton College of Technology where Richard Goodman directs the Department of Cybernetics. Workers here will subject existing British and American machines and programmes to operational tests to provide a "consumers' guide" to their qualities. New programmes on management studies and other topics are also being developed. Machines and programmes are being used in the teaching of Spanish by W. Mills at Coventry Technical College (see Figure 10).

Perhaps the most exciting work, however, is still being done by Gordon Pask (mentioned at the beginning of this chapter), who was visiting professor in the University of Illinois for a time. He founded his Systems Research Ltd. some years ago and was recently joined by B. N. Lewis who worked on adaptive mechanisms for a time at Birkbeck College, London University. Pask has developed extrinsically adaptive teaching machines, the best known being concerned with perceptual-motor skills. His well-known SAKI (Solatron Automatic Keyboard Instructor) is now being produced in improved form by Cybernetics Developments Ltd. Adaptive machines have many applications in teaching keyboard skills as well as equipment-servicing and other skills. Lewis reports that a prototype typewriting instructor has been recently constructed, and machines using similar methods have been used successfully in the training of Morse, ad-listing, and telephone dialing operations; piano playing instruction has not yet been automated (but is theoretically possible!) in spite of complex criteria such as "style." A further development by Pask and his colleagues is in the field of automated group instruction. This can take the form of computer-controlled classes using pre-programmed material as in PLATO at Illinois. An alternative method being developed by Pask, is to use the machine to manipulate students in a group so that they teach each other.

So much for machines and programmes, what sources of information exist in the United Kingdom?

An Association for Programmed Learning was set up in January 1962 by a group of teachers and lecturers chiefly from the London area. Branches are now being formed in many parts of the country. The Association sets out to act as a clearinghouse of information -- issuing bulletins, lists of programmes, programmes and machines, arranging lectures and conferences, and assisting research projects. For example, a one-day conference was held at Birkbeck College, London, on January 1, 1963, and followed by a three-day course on programming.

Other courses and workshops have been organised by the Psychology Department of Sheffield University, in Sheffield; by the College of Technology of Brighton, at Brighton; and by the Department of Education at Sheffield University in several centres including Manchester and Bristol.

Similar courses have been organised by LEA's, teachers' organisations, and colleges. Unfortunately, as in the early days in the United States, the number of people able to lecture on programming has been limited and the burden has usually fallen on the same individuals. Great interest was aroused by recent visits to England by Skinner and Crowder. Conferences concerned with Commonwealth and overseas countries have led to requests for visits by British authorities, and to opportunities for British workers to visit North America. The writer recently took part in a conference in the House of Commons, organised by the Overseas Development Institute and the Council for Education in the Commonwealth to discuss the place of programmed learning and teaching machines in developing countries. James Hartley is, this summer, taking part in work in Jordan, at the request of UNESCO. Richard Goodman has visited South Africa and the writer is lecturing in the University of British Columbia at Vancouver, and in the University of Michigan during the summer.

Publications in the United Kingdom have followed a similar pattern to that in the United States -- a spate of "popular" articles followed by a small stream of research results. Some of these are listed at the end of this section.

The first British books on the subject are making their appearance in 1963 -- an Introduction termed "Mechanisation in the Classroom," edited by Maurice Goldsmith, contains articles by several British authorities. A small handbook by Richard Goodman on this field has been published by EUP. A symposium edited by the writer is to be published by Pergamon Press this summer (1963).

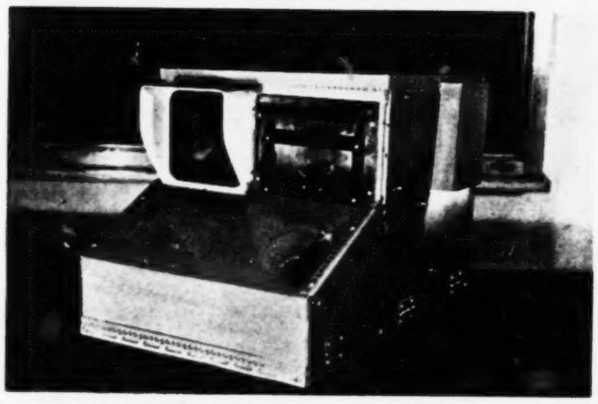

Fig. 1. The Sheffield teaching machine
(Courtesy - John Annett & Max Sime)

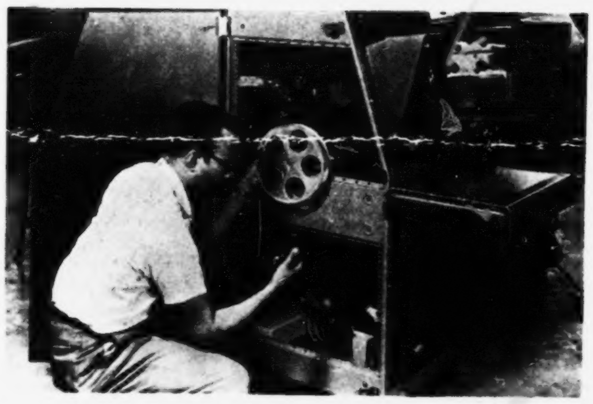

Fig. 3. Autotutor Mk II
(Courtesy - U. S. Industries [Gt. Britain] Ltd.)

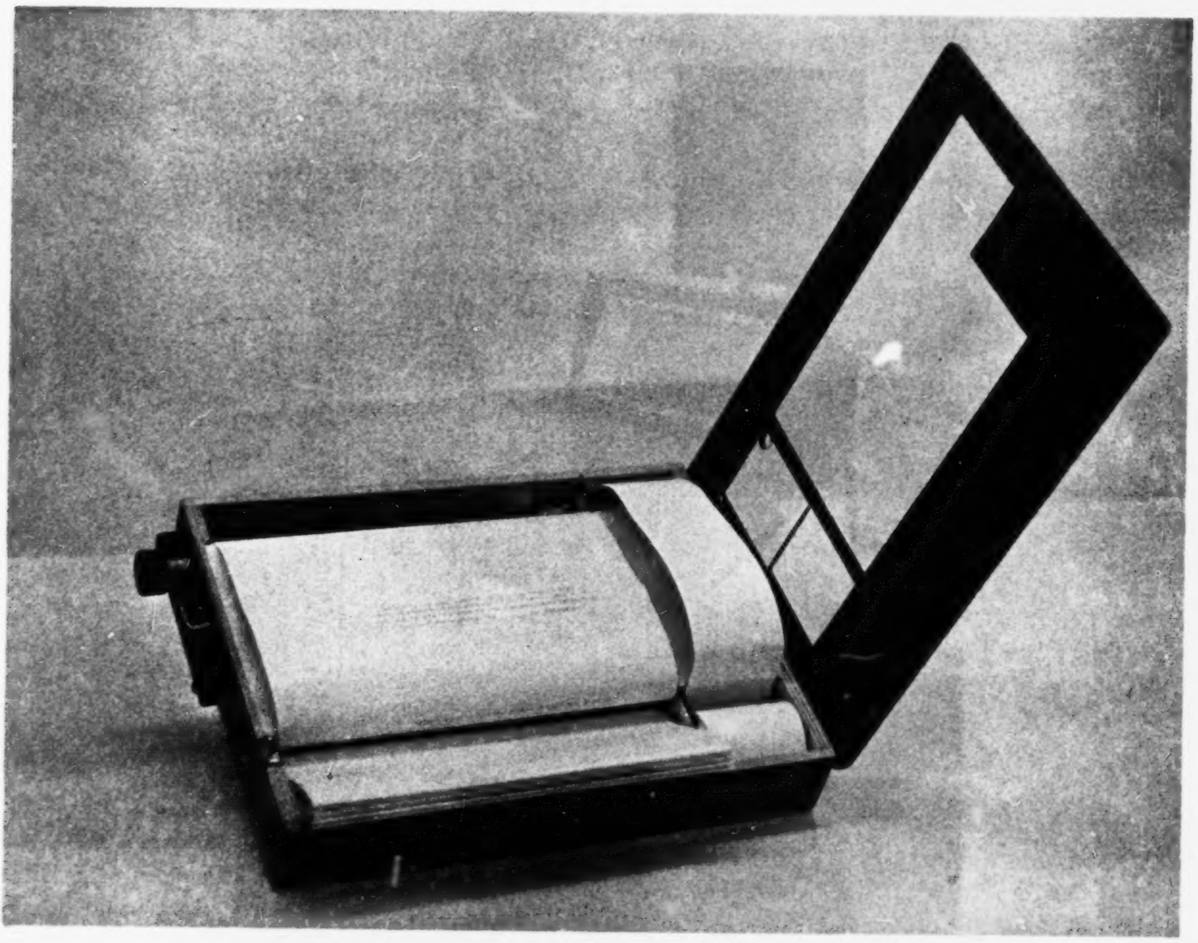

Fig. 2. Aberdeen machine using fan folded paper
(Courtesy - Leslie Reid)

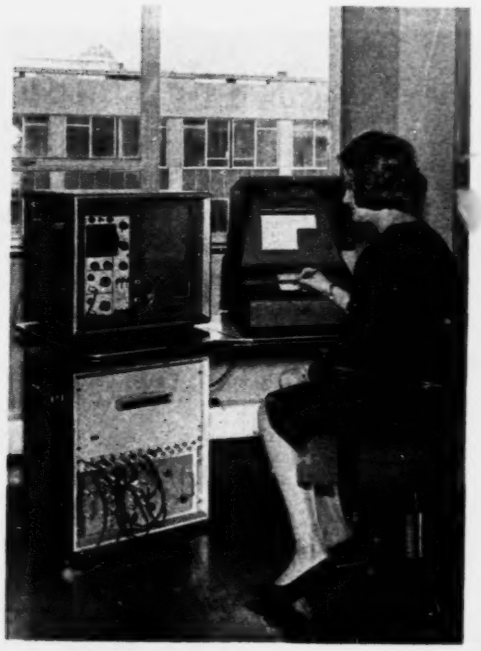

Fig. 4. The Empirical Tutor
(Courtesy - Lamson Technical Products Ltd.)

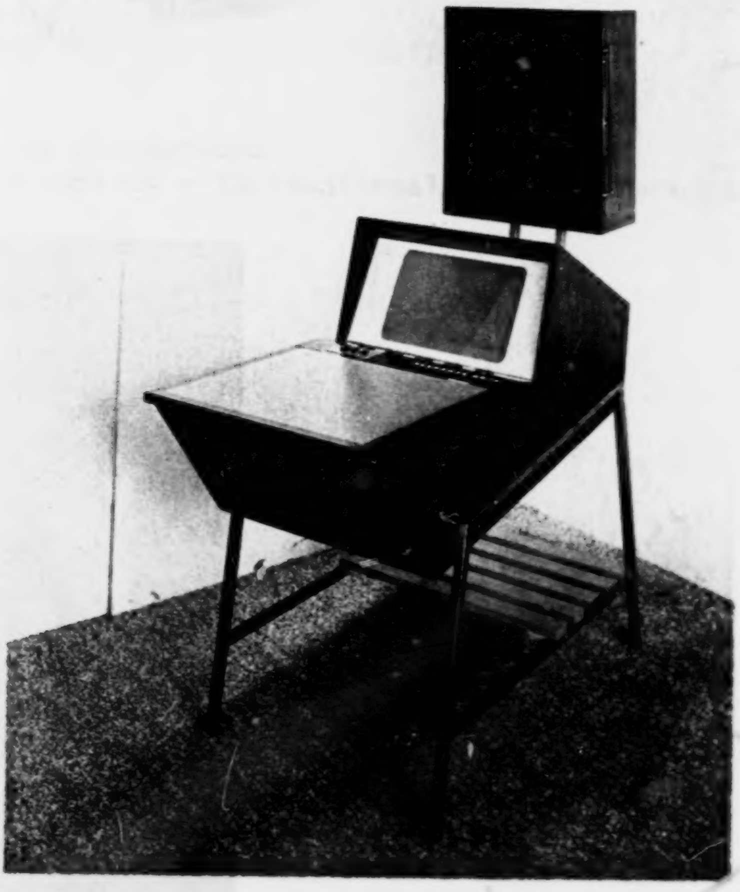

Fig. 5. The Clements machine
(Courtesy - Clements Bros., Bromsgrove, Worcs.)

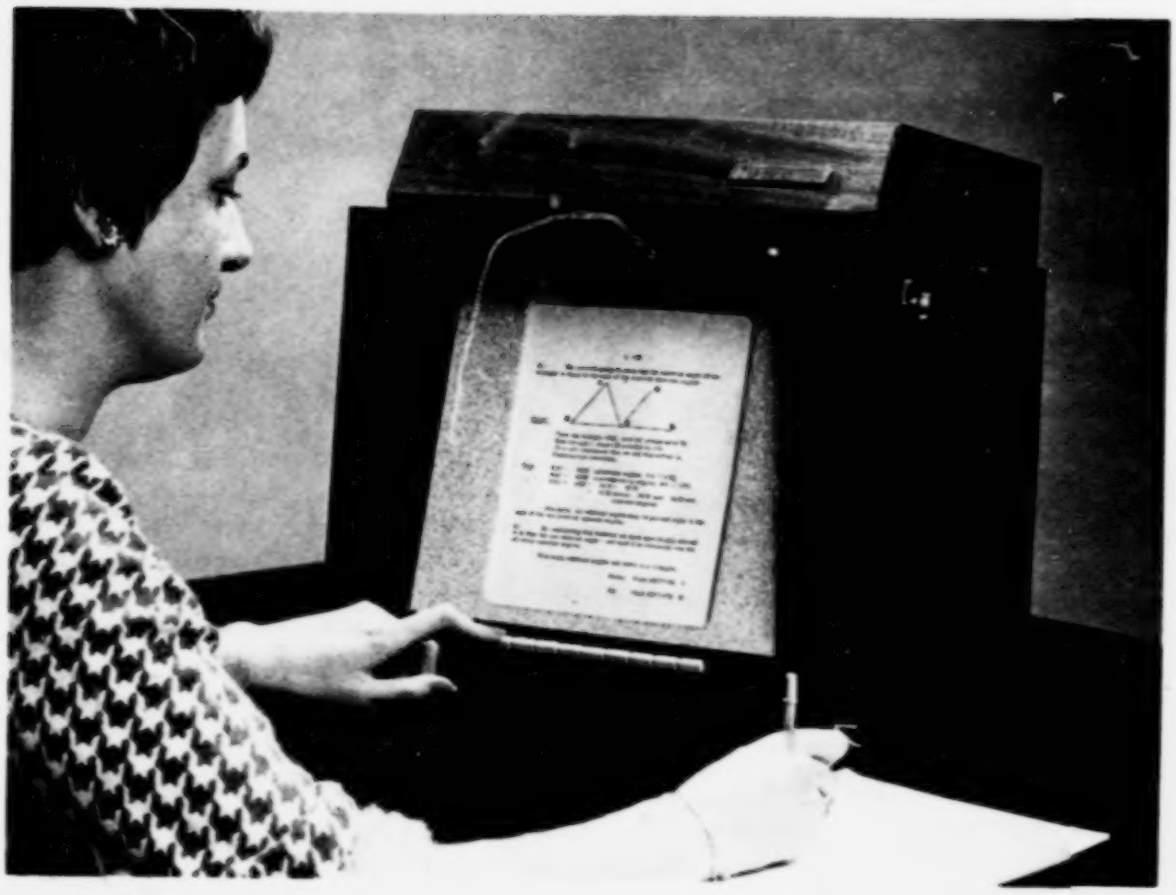

Fig. 6. The Grundytutor
(Courtesy - International Teaching Machines)

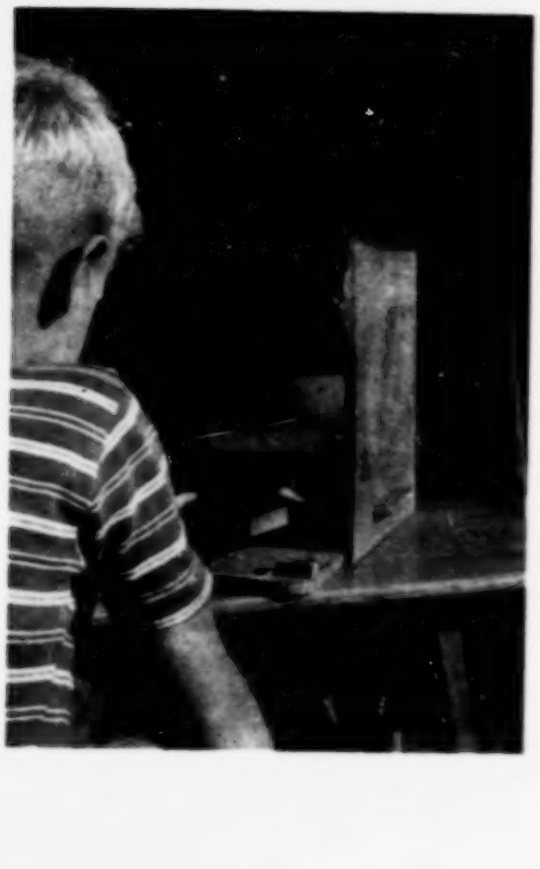

Fig. 7. Prototype multiple-choice device used in Kent
(Courtesy - Peter Chapman)

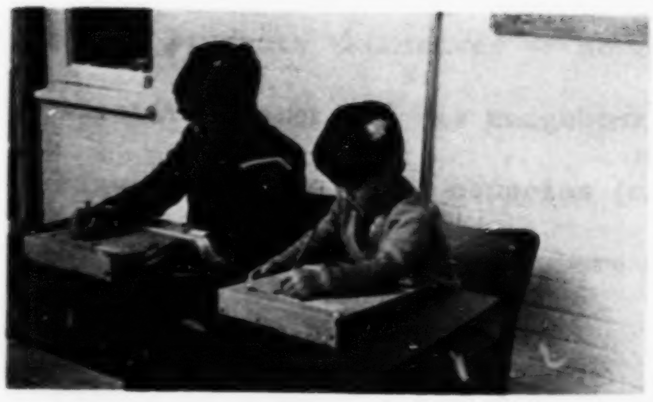

Fig. 8. The Tutorpack
(Courtesy - P. J. Packman)

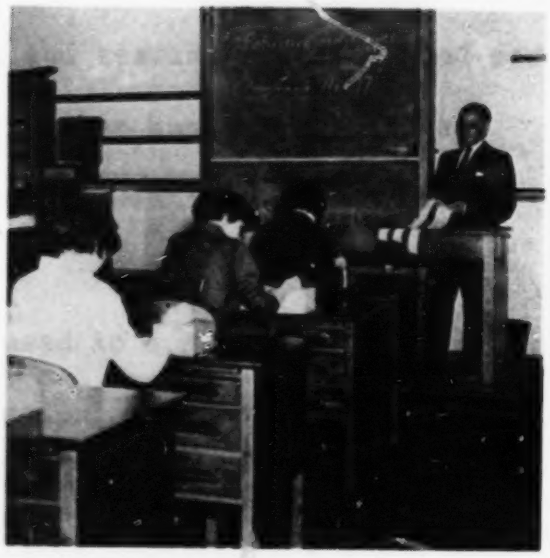

Fig. 10. Machines and programmes used in the teaching of Spanish
(Courtesy - W. Mills)

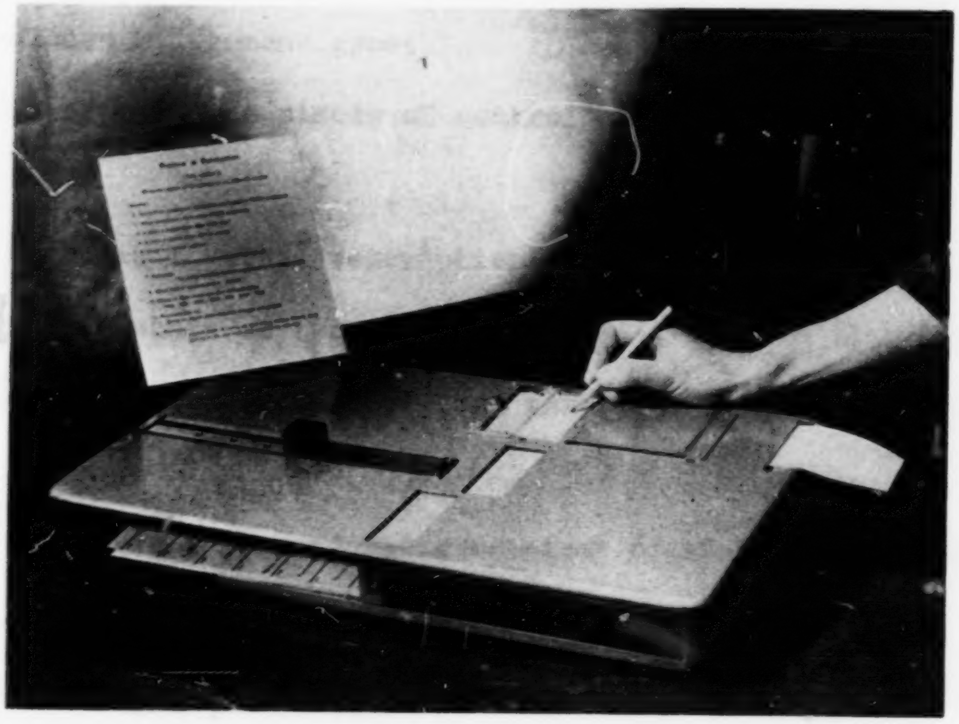

Fig. 9. The Esatutor
(Courtesy -- Educational Supply Association)

Figures 11 to 13 (which follow on pages 17, 18, and 19) show parts of a special kind of tuition system in which members of a 3-person group are induced to teach each other. Whereas the conventional teaching machine assumes direct responsibility for instructing and testing students, and for resolving their difficulties, this particular system hands these duties over to the students themselves -- so that each student's progress becomes the collective concern of his neighbours.

Figure 11 shows three consoles (each housed in a separate soundproof cubicle) which the three group members must manipulate in order to communicate with and teach each other.

Figure 12 gives a close-up view of a console containing a 9 x 9 display of 81 diagrams for use in the communication of ostensibly defined concepts. This particular console could equally well have been equipped with a display of the kind used in training students to diagnose faults in electrical circuits. Alternatively, the display could be of a type suitable for use in business management games.

Figure 13 shows three pieces of control apparatus standing side by side.

On the right is a "state description console" which gives a move-by-move account of the state of the group activity, and which also exhibits a variety of success measures (to show, for instance, who is learning from whom).

In the middle is a "procedural automaton" which sequences and monitors successive stages of the group activity. This automaton acts as a sort of external environment to the group, in that it provides the group members with information that they can either act upon or ignore.

On the left is an "over-all controller" which adjusts the working conditions of the group so as to encourage patterns of activity that look promising. To achieve the appropriate adjustments, the over-all controller samples the success measures appearing on the state description console, and assigns greater control (over the group activity) to those members who seem to be contributing most to the required group objectives. The result is an adaptive control system which effectively functions as a catalyst. It potentiates a wide variety of behaviour patterns in the group, in order to select out and perpetuate those that achieve the highest pay-off.

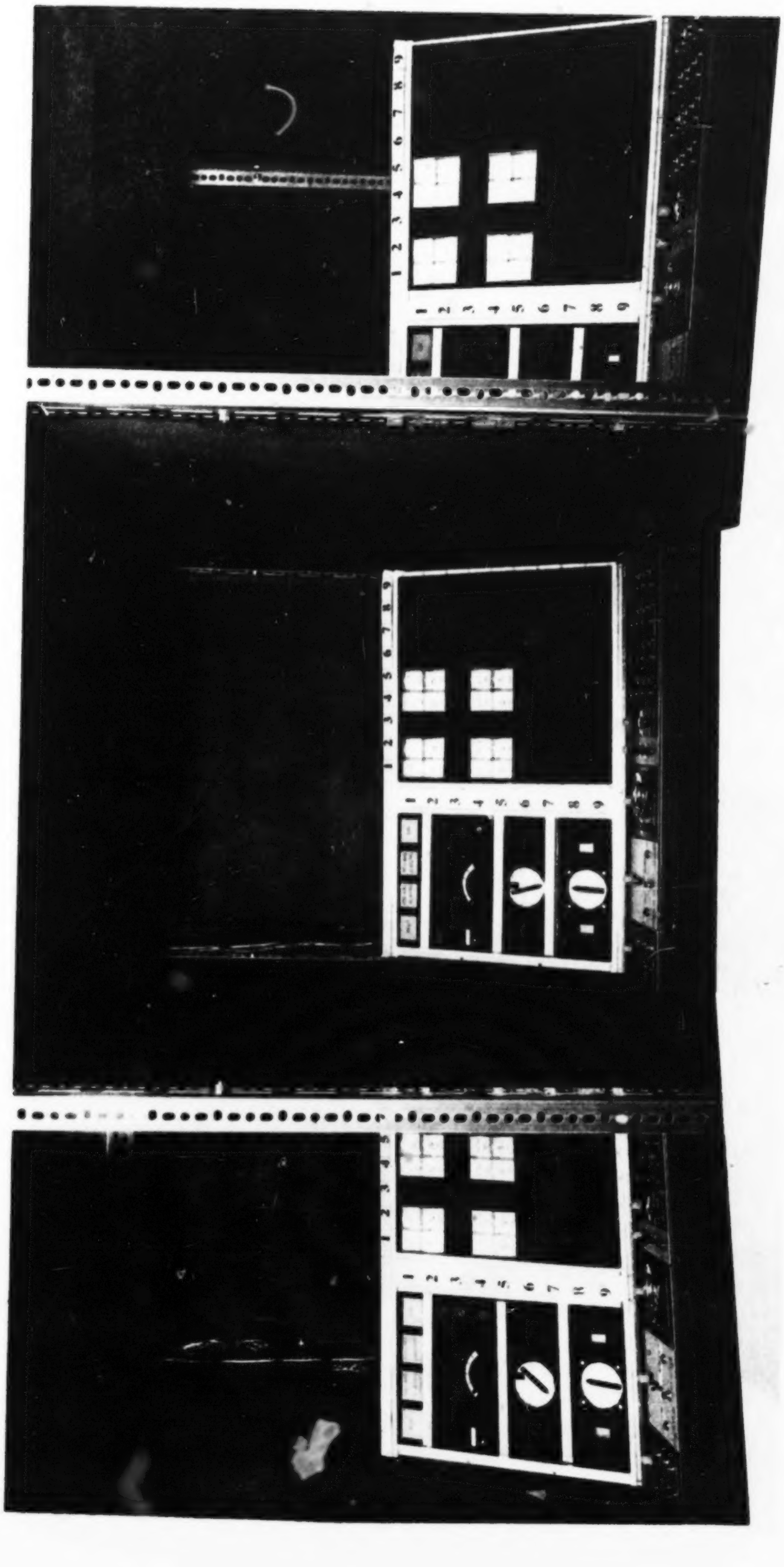

Figure 11.

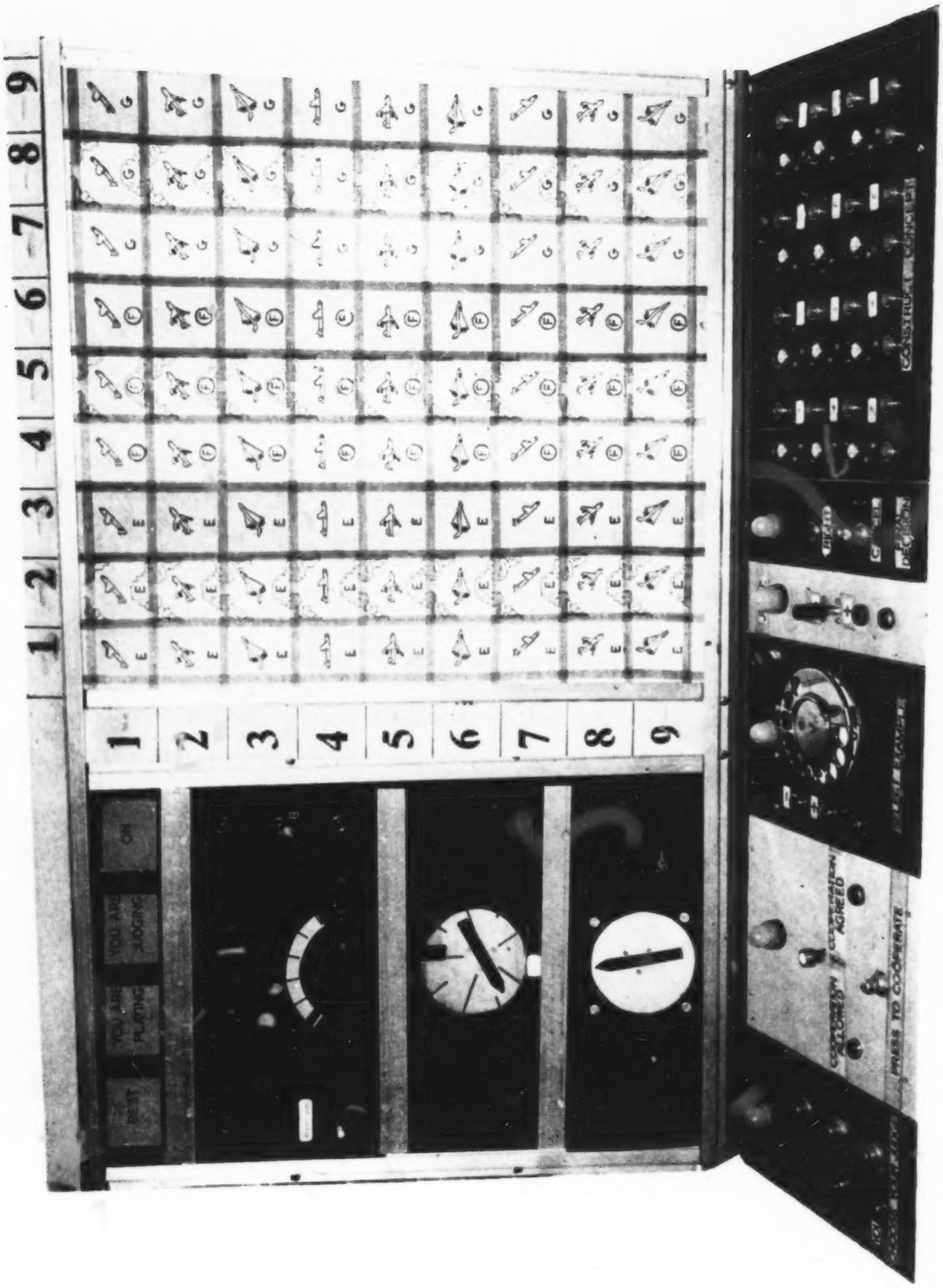
1
2
3
4
5
6
7
8
9
ON
YOU ARE JUDGING
YOU ARE PLAYING
COOPERATION AGREED
PRESS TO COOPERATE
DECISION

Figure 12.

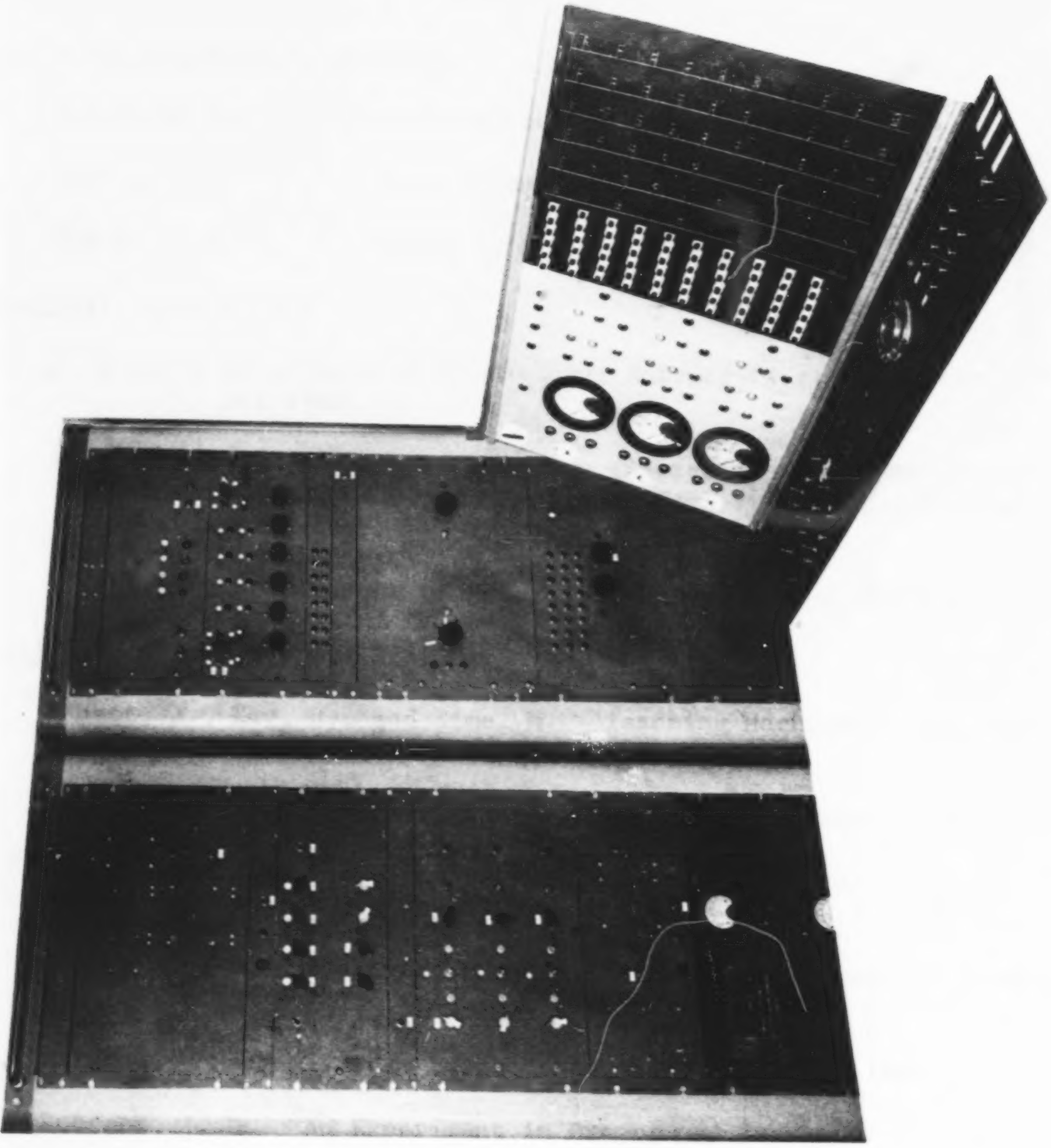

Figure 13.

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CONFIDENTIAL PRE-COPY

THE DEVELOPMENT OF PROGRAMMED INSTRUCTION IN JAPAN

by

Mitoji Nishimoto

Director, Audiovisual Center

International Christian University

I. The Beginning of Programmed Learning and Teaching Machines

The history of teaching machines and programmed learning in Japan is very short. The present writer found an article by A. A. Lumsdaine on "Teaching Machines and Self-Instructional Materials" in the summer 1959 issue of the Audio-visual Communication Review. He was very much interested in Dr. Lumsdaine's article and decided to take up this topic at the Seventh National Conference on Audiovisual Education, an annual meeting which has been held on the campus of the International Christian University since the summer of 1954.

In December 1959, Ben C. Duke, a new Ph.D. from Pennsylvania State University, joined the ICU Audiovisual Center. He was assigned to collect the materials of teaching machines and programmed learning for the 1960 Summer A-V Conference on the ICU campus. During the Seventh National A-V Conference, July 25 to July 27, 1960, some American printed materials of programmed learning were displayed and two introductory speeches on teaching machines and programmed learning were delivered by the writer and Dr. Duke. This was the first attempt in Japan to introduce the movements of programmed learning which had been developed in the United States.

The manuscripts of two speeches at the conference were printed in the September number, 1960, of the monthly magazine Radio-TV Education (Hosokyoiku) as follows:

"Teaching Machines and TV Education," by Mitoji Nishimoto

"Teaching Machines and AV Education," by Ben C. Duke

In November 1960, Hajime Yaguchi commented on Japanese audiovisual education from the standpoint of the programmed learning at the Tenth National Audiovisual Convention held in Kyoto. This speech was also printed in the January number, 1961, of the monthly magazine, Audiovisual Education.

Enlightened by these speeches and magazine articles, Japanese teachers and publishers and some electronics manufacturers have become interested in these new techniques and devices of education. Newspapers, weekly magazines, and television also have performed their roles in arousing the interest of people concerning the problems of teaching machines and programmed learning.

II. The Role of ICU A-V Center

During the Christmas vacation of 1960, Dr. Duke visited the United States to obtain the information and materials of programmed learning. He visited San Francisco, Los Angeles, Chicago, New York, and Washington, D. C., and brought back to the Center the following materials:

(a) Printed materials:

Tutor Texts (Doubleday), High School Physics, I, II
(American Institute for Research), Temac Programs (EBF),
Self-tutoring Programs (TMI-Grolier)

(b) Filmstrips:

Teaching Machines (Basic Skill Films)
An Example of Programs (Basic Skill Films)

(c) Machines:

Min/Max (TMI-Grolier), Automated Teaching Machines
(Foringer), Ferster Tutor (Programmed Teaching Aids),
Didak (Rheem Califone Corporation), Star (HRB-Singer)

These printed materials, teaching machines, and filmstrips were displayed and screened. Four lectures and a symposium on programmed learning and teaching machines were delivered during the Eighth National Conference on Audiovisual Education which was held on the ICU campus in July 1961. The titles of the lectures and symposium were as follows:

Ben C. Duke: "Developments in the American Teaching Machine Field--Implications for Japanese Education"

Maurice E. Troyer: "Some Psychological Considerations Basic to the Effective Use of Teaching Machines"

Mitoji Nishimoto: "Present Status and Future Development of Teaching Machines and Programmed Learning in Japan"

Akio Yamawaki: "A Practical Method of Teaching by Synchrofax"

Symposium: "Teaching Machines and Automated Learning" by M. Nishimoto, K. Hatano, R. Ono, A. Yamawaki, S. Tanaka

In July 1962, at the Ninth National Conference on Audiovisual Education on the ICU campus, the writer delivered a lecture in which he described the development of new educational media including teaching machines and programmed learning based on his observations during his trip to the United States from October to December, 1961, and to Europe and America from March to April, 1962. He also conducted a symposium on "Research on Programmed Instruction," and displayed many printed materials on programmed learning which he had collected during his last two trips through the States. The following films which he brought back from his last trip were screened:

Teaching Machines and Programmed Learning (NEA)

Reinforcement in Learning and Extinction (McGraw-Hill)

Controlling Behavior through Reinforcement (McGraw-Hill)

Learning Discriminations and Skills (McGraw-Hill)

The ICU Audiovisual Center published the Japanese edition of "Teaching Machines and Programmed Learning" published by NEA so that the development of programmed learning in the United States may be well understood among the teachers and the people concerned.

Thus the ICU Audiovisual Center did its best in introducing the new methods and techniques in education. The Center is also advising some publishers in developing the materials of programmed learning. It also helps graduate students develop English programs of junior high school level.

III. The Role of the National Confederation of the Organization of Programmed Learning

Hajime Yaguchi, chief of the instructional materials office of the National Institute for Educational Research, has been active in promoting the programmed instructional movement since 1961. He started an automated learning study group in Tokyo in 1961. He has cooperated with the Mizukaido Elementary School in Ibaragi Prefecture, several elementary and secondary schoolteachers in Toyama Prefecture and Oita Prefecture to develop instructional programs. During the years 1961 and 1962, there were about 2,000 schools which were engaged in constructing programs in the four islands of Japan. Some of them are producing fine programs, and the others are imitating patterns constructed by other teachers.

But many of these pioneers are anxious to change the traditional materials and methods of teaching. They have organized more than 30 prefectural or municipal associations so that the group of schools may exchange their ideas and cooperate with each other to develop better programs. In 1963, they inaugurated the National Confederation of the Organization of

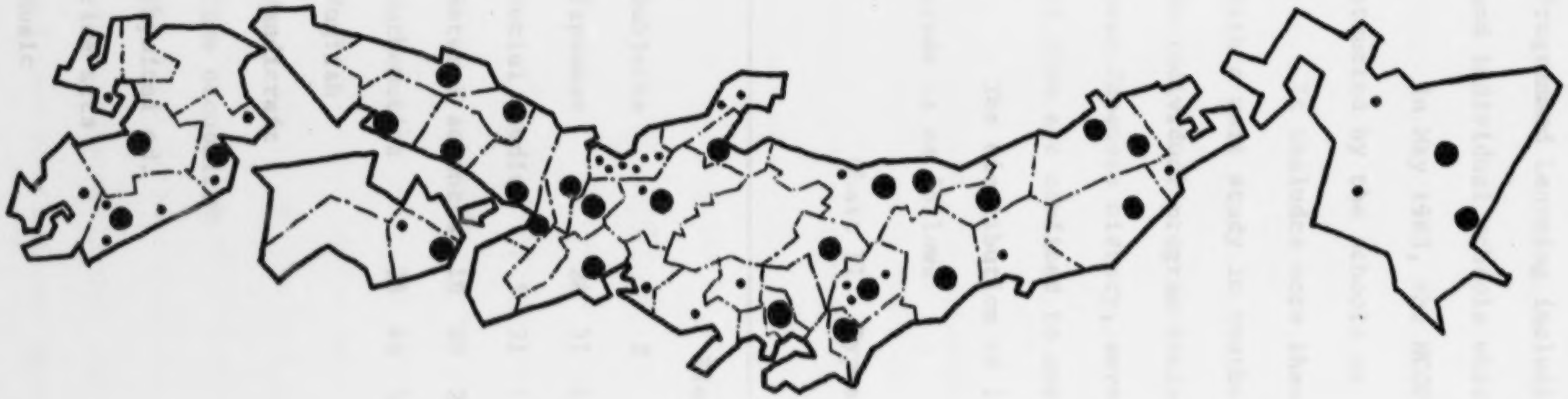

Chart I. Distribution of Programmed Learning Study Centers

This chart indicates the distribution of the prefectural, municipal organizations and local or small groups of teachers which are taking part in developing instructional programs for programmed learning.

Note: (1) The large dots indicate the city or prefecture where the programmed learning study group is organized.

(2) The small dots indicate the school or groups of teachers initiating studies of programmed learning.

Programmed Learning including the 30 prefectural and municipal associations and individual schools which have not yet been organized.

In May 1963, the NCOPL published a list of programs which were constructed by the schools or teachers who are the members of the Confederation. It includes more than 1,300 programs. But most of them are concerned with a unit study in textbooks. Steps in each unit vary from 10 to 800. No individual program includes its whole area of a subject, such as sixth-year Japanese history, seventh-year algebra, or ninth-year physics. Most of them are confined to one lesson of one textbook.

The distribution of 1,330 programs according to subject matter of each grade is as follows:

Chart II. Types of Programs, Reported to NCOPL
May 1963

	Elementary						Jr. High			Sr. High			
Subjects	1	2	3	4	5	6	7	8	9	10	11	12	Total
Japanese	26	31	42	48	48	56	13	11	11				286
Social studies	5	21	16	53	62	27	45	30	10				269
Natural sciences	18	29	25	27	44	55	19	21	9			40	287
Mathematics	25	40	58	71	71	62	25	26	14	14			406
English							22	5	7	3	2		39
Handicraft							4	16	2				22
Home economics									9				9
Physical ed.								3					3
Fine arts							2	3					5
Music							2		2				4
Total	74	121	141	199	225	200	132	115	64	17	2	40	1,330

All programs have been constructed by elementary and secondary schoolteachers to use in their own classrooms. The programs are, therefore, closely related to each lesson in the textbook. The methods and techniques of building the steps are more or less similar to the traditional ways and means of classroom instruction. This is the weak point of the existing programs in Japan.

The NCOPL is planning to have a library of these programs so that the programs may be printed by means of recopying and will be distributed to the classrooms. Thus the programs will be evaluated and improved.

IV. Tamagawa Sheet Learning

Since April 1961, the junior high school of Tamagawa Gakuen started program learning in algebra by using Ricoh Synchrofax. Akio Yamawaki, a teacher of mathematics of the junior high school department, constructed a series of programs in algebra and printed them on the sheets. On the other side of the sheets, he put a magnetic recording, giving vocal instruction in how to solve the problems.

The Ricoh Synchrofax was originally invented in Japan around 1958 for businesses and offices chiefly, to send sheets of talking letters, drawings, photographs, with the combination of printed materials on the one side and magnetic sound on the other.

The Synchrofax is a magnetic recording and play-back device, which appeals to both eye and ear simultaneously. The maximum recording time of one sheet is four minutes. When the recorded materials contents are no longer preserved, they can be easily erased with an exclusive attachment and used over and over again. Any number of copies can be reproduced from a particular sound sheet. This sheet can be filed, kept or folded, and

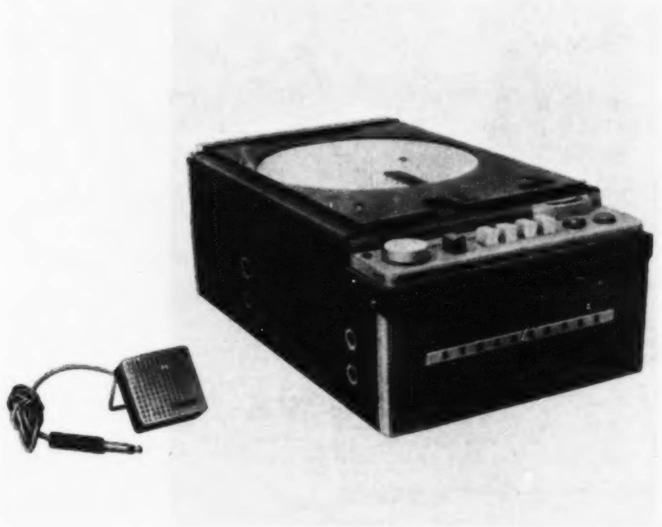

Fig. 1. Ricoh Synchrofax - Model II

A sheet-recorder which records and plays back.

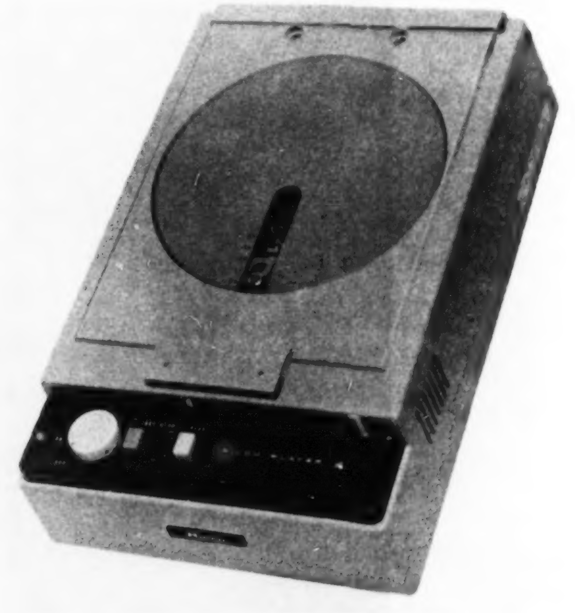

Fig. 2. Ricoh Synchro-Player

A machine which plays back the recorded contents on the sheet.

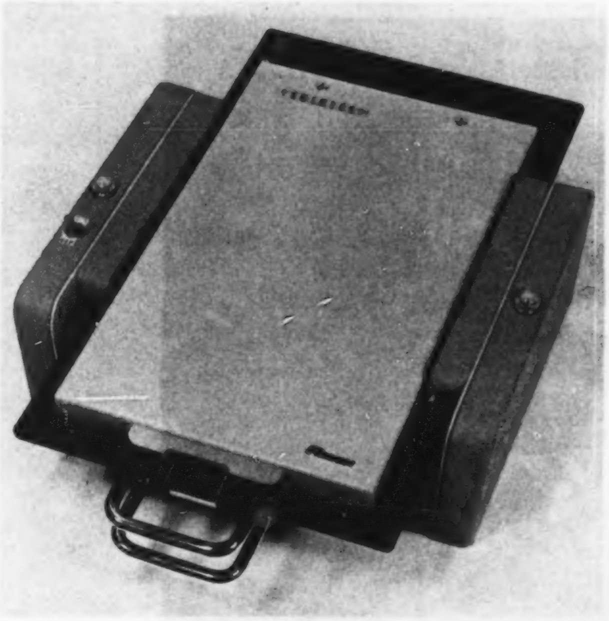

Fig. 3. Ricoh Printer

An apparatus which produces the recorded contents, copies from the original recorded sheet.

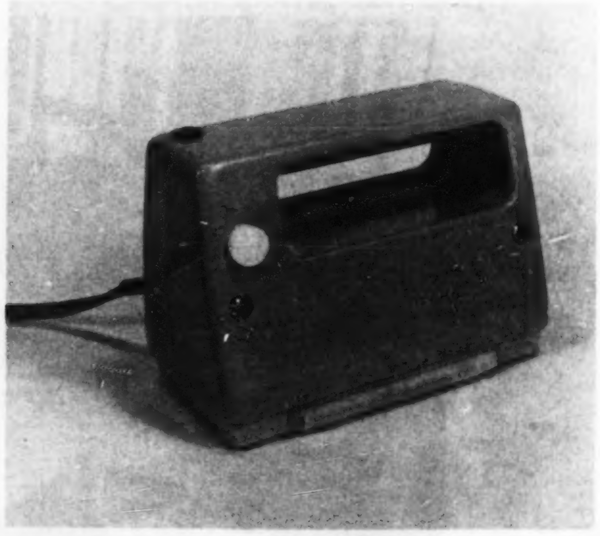

Fig. 4. Ricoh Hand Eraser (I)

Eraser which erases the recorded contents on the sheet and can be operated by hand.

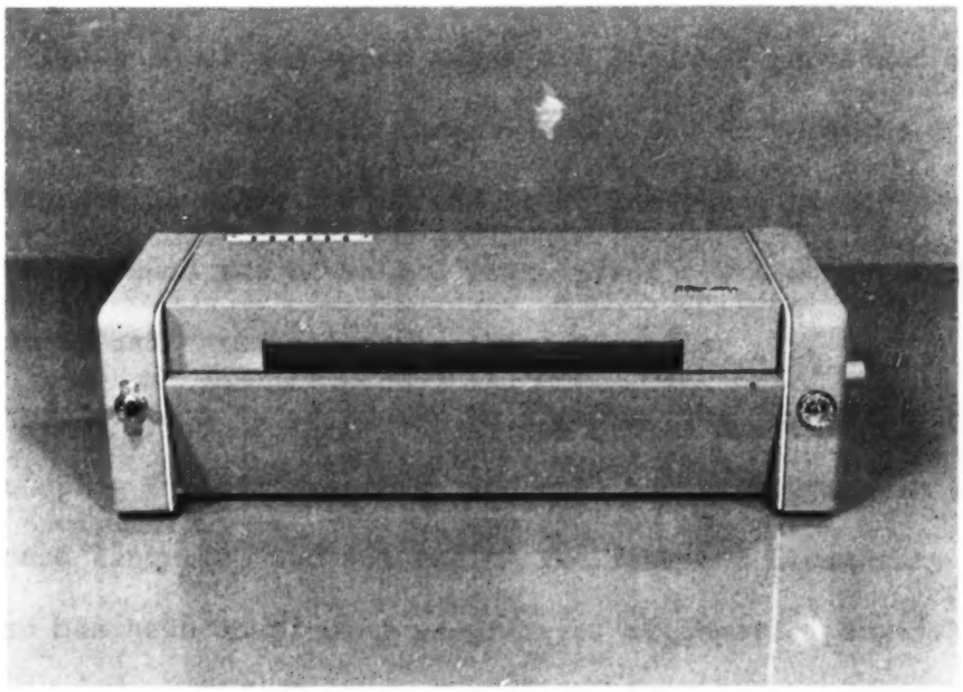

Figure 5. Ricoh Eraser (II)

Eraser which erases the recorded contents on the sheets, about 10 sheets at a time.

Figure 6. Ricoh Synchrofax machines are used in many Japanese schools as an audio-visual aid.

sent by mail without affecting the quality of the sound. On the reverse side of this sheet, facts about the sound materials or other pertinent information may be printed, typed, or written, thereby appealing to both the eye and the ear. The Ricoh machine sells for around $100, including microphone.

A sheet with sound and black and white print costs about 15 cents, and a sheet with sound and three colors is about 23 cents.

After experimenting successfully in algebra, the Tamagawa Junior High School is developing English programs, and will begin programs in social studies, Japanese language, and science. The Tamagawa Elementary School Department also has been developing programs of arithmetic, English, Japanese, and music. The Senior High School Department is now planning to produce programs of various subjects for the tenth, eleventh, and twelfth grades.

Some of the sheets programmed by the teachers of Tamagawa schools have been used for instructional materials by the teachers in various parts of the country, especially in Tokyo and Osaka, and in Aichi, Okayama, and Hiroshima Prefectures. These teachers also are experimenting with programs of various subjects. There are about 1,500 elementary school teachers and about 300 junior high school teachers, who are participating in producing and utilizing programmed learning sheets.

V. The Publications on Teaching Machines and Programmed Learning

Since 1961, many books on programmed learning and teaching machines have been published. Most of them are more or less introductory in nature. Following is the list of books in chronological order:

A. Books

1. Murai, M. and Numano, K. The teaching machine, Maki Book Co. 1961

2. Numano, K. Introduction to programmed learning, Kodansha Publishing Co. 1962
3. Yaguchi, H. Principles and practice of automated teaching, Shogakkan Publishing Co. 1962
4. Yaguchi, H. Theory and methods of programmed learning, Meiji Book Co. 1962
5. Yaguchi, H. Introduction to programmed learning, Kokudosha Book Co. 1962
6. Hatano, K. and others. Introduction to programmed learning, Shogakkan Publishing Co. 1962
7. Nishimoto, M. and Obara, K. Teaching machine and reconstruction of methods, Tamagawa University Press. 1962
8. Kami-iizaka, Y. Programmed learning for mothers, Kodansha Publishing Co. 1962
9. Koshimizu, M. Programmed learning for language skills, Meiji Book Co. 1962
10. Koshimizu, M. Theory and practice of programmed learning in Japanese language, Shinkakaku Publishing Co. 1963
11. Ikeda, S. and Suzuki, S. The programming for Japanese language teaching, Meiji Book Co. 1962
12. Kaneko, M. Structure and function of programmed learning, Japan Bunka Kagaku Publishing Co. 1963

B. Books, translated

1. Nishimoto, M. and others. Teaching machines and programmed learning by A. A. Lumsdaine and Robert Glaser, ICU A-V Center. 1961
2. Numano, K. and others. Adventure to algebra by N. Crowder, Miki Book Co. 1962
3. "Science of Learning" Study Group. Introduction to electronics by R. Hughes and P. Pipe, Maki Book Co. 1963

In Japan, there are about ten major textbook publishing companies. They are eagerly looking forward to publishing programmed texts, and are now very carefully keeping their eye on the future development of programmed learning.

At this moment, some of the textbook publishers are mainly concerned with the programmed texts of mathematics and English on the junior high school level, and arithmetic and Japanese language on the elementary school level.

The following texts are on sale now:

1. Junior High School Level
    - a. English
        - (1) Gakken Machine Books, Vols. 1-10, Gakken Publishing Co.
        - (2) Programmed Learning, Vols. 1, 2, 3, Shogakkan Publishing Co.
    - b. Mathematics
        - (1) Automated Mathematics, Vols. 1, 2, 3, Gakken Publishing Co.
        - (2) Programmed Learning, Vols. 1, 2, 3, Shogakkan Publishing Co.
        - (3) Programmed Book, Vols. 1, 2, 3, Osaka Book Co.
2. Elementary School Level
    - a. Arithmetic
        - (1) Automated Arithmetic, Grades 3, 4, 5, Gakken Publishing Co.
        - (2) Programmed Learning, Upper Grade, Vols. 1 and 2, Shogakkan Publishing Co.
        - (3) Programmed Book, Vols. 1, 2, 3 (for 2-6 grades), Osaka Book Co.
        - (4) Arithmetic Programmed Text, Vols. 1 and 2 (for 5, 6 grades), Kodansha Publishing Co.
        - (5) Arithmetic Programs, Vols. 1, 2, 3, 4, 5, 6 (for 1-6 grades), Nippon Standard Test Institute
    - b. Japanese Language
        - (1) Automated Japanese Language, Vols. 1, 2, 3 (for 3-5 grades), Gakken Publishing Co.
        - (2) Language Skill Books, Vols. 1, 2, 3, 4, 5, 6 (1-6 grades), Kobun Book Co.
        - (3) Japanese Language Programs, Vols. 1, 2, 3, 4, 5, 6 (1-6 grades), Nippon Standard Test Institute
    - c. Natural Science
        - (1) Science Programs, Vols. 1, 2, 3, 4, 5, 6 (1-6 grades), Nippon Standard Test Institute

d. Social Studies

(1) Social Studies Programs, Vols. 1, 2, 3, 4, 5, 6
(1-6 grades), Nippon Standard Test Institute

No university programs or vocational programs on this level have been attempted, but in a few years development on this level will rise to meet the development of more advanced instructional machines.

VI. Teaching Machines Produced in Japan

In addition to the Synchrofax, mentioned in item IV, there are more than half a dozen teaching machines produced in Japan.

In about 1959, the Gakken Publishing Company in Tokyo produced a small, simple, inexpensive gadget, called "Gakken Memorizer," to help children study English by program. They constructed a program of 288 sentence patterns of English for beginners, and printed them in six rolls, 48 sentences in each roll. Each roll is put one after another in the case of 3.5 x 3 x 0.8 inches, as the lesson proceeds. The present model has not yet made much progress, but the company is planning a better model.

Since 1960 when American teaching machine movements were introduced, the Gakken Publishing Company has been very much interested in programmed learning, and set up two departments, the one for programs, the other for machines. The program department has already produced two programs, English and mathematics, while the machine department has succeeded in producing three machines.

KEY-PET is a teaching machine especially designed for little children. Each problem on an inserted roll has four answers. The child pushes the number he thinks correct, and if the answer is correct, the buzz will sound and the light will flash. About two hundred program rolls are now available.

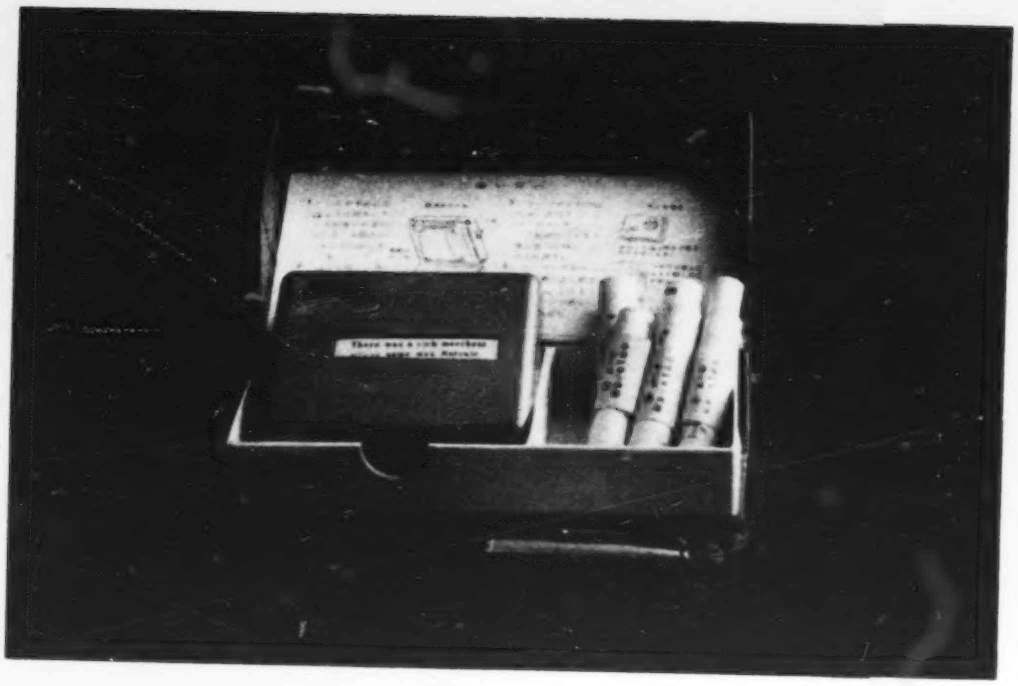

Figure 7. Gakken memorizer.

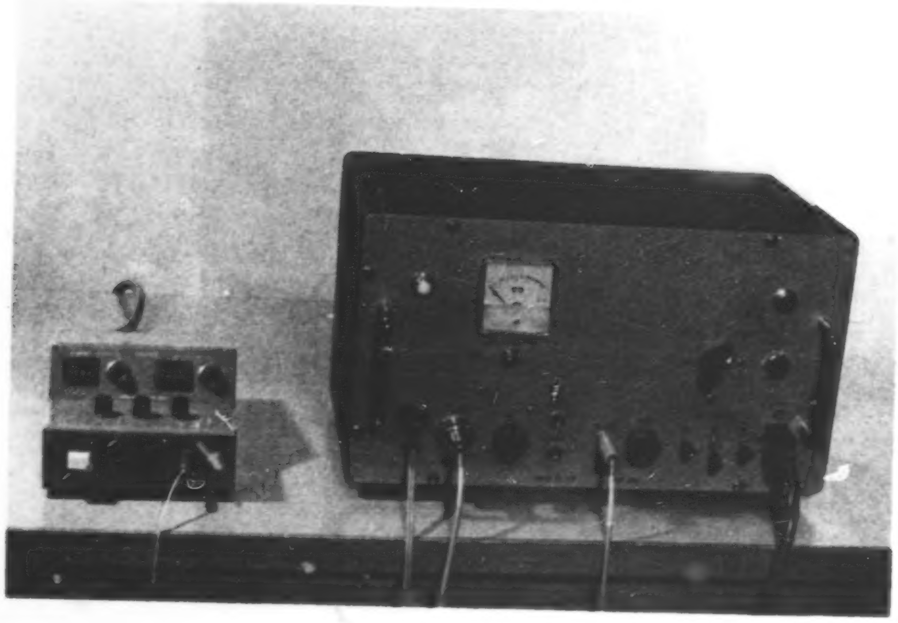

Figure 8. Gakken auto-trainer (Type A).

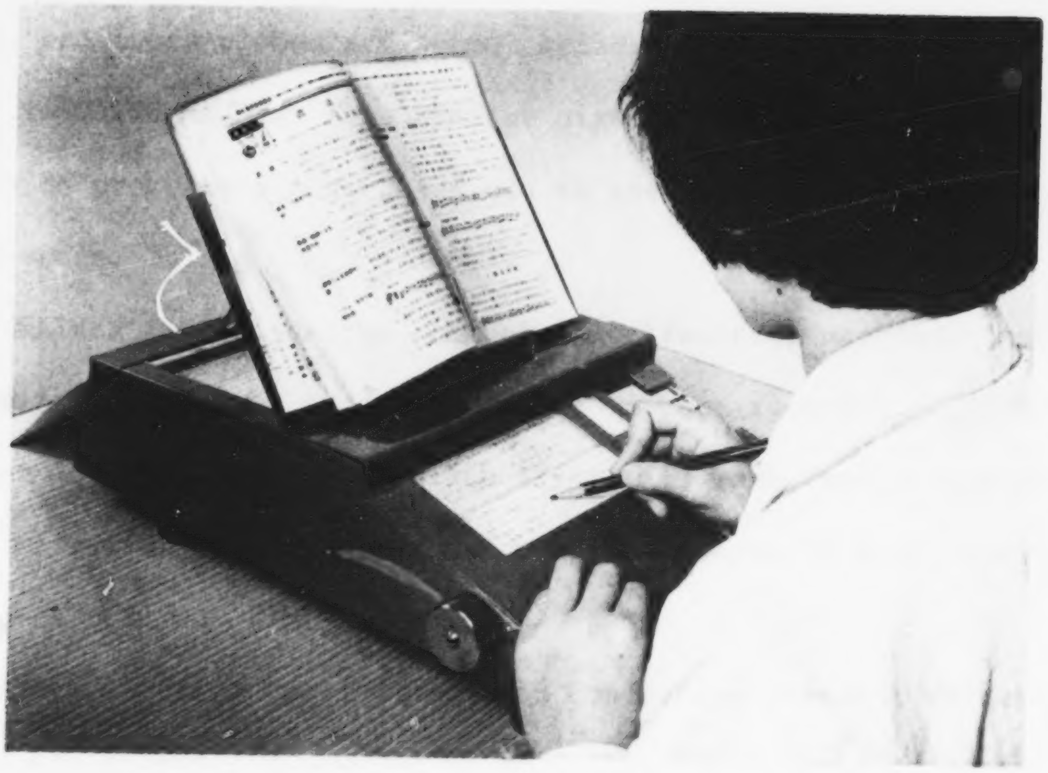

Figure 9. Gakken teaching machine - S-3.

Figure 10. Children are using KEY-PET.

The subjects are Japanese, arithmetic, science, and social studies, all for kindergarten and lower elementary school children.

S-III TEACHING MACHINE is a similar size to "Min/Max" by T.M.I. in using sheets of programmed paper, and can be used for both constructing and selecting answers.

AUTO-TRAINER is a classroom communication teaching machine. Audio-visual stimuli are given by an auto-slide and a tape recorder. If the student's answer is correct the blue flash light will work, and if not correct the red one will flash. Both right and wrong responses in each case can be recorded.

The Nippon Electric Company has been conducting research on teaching machines and has recently succeeded in producing three types of machine.

NEC-TMa is the largest ever developed in Japan. It can be divided into three blocks: i.e., a display unit, a control unit, and a magnetic tape recording system. On the front panel of the display unit, there are a screen, five kinds of push buttons to select answers, and two operating buttons. After matching a title and the first problem projected on the screen, and hearing an explanation from the tape recorder, the student chooses one answer which he thinks correct among five kinds of answers simultaneously projected on the screen, and pushes a button corresponding to the number of the answer. Then, the artificial brain of the control unit judges the answer, and if it is correct, the equipment offers a little more difficult problem. If the answer is wrong, the machine presents an easier problem corresponding to the kind of error. If the student solves it correctly, the device submits the next problem. If his answer to the easier problem is again erroneous, the equipment gives him the answer to the first problem and its explanation and he hears an instruction from the tape

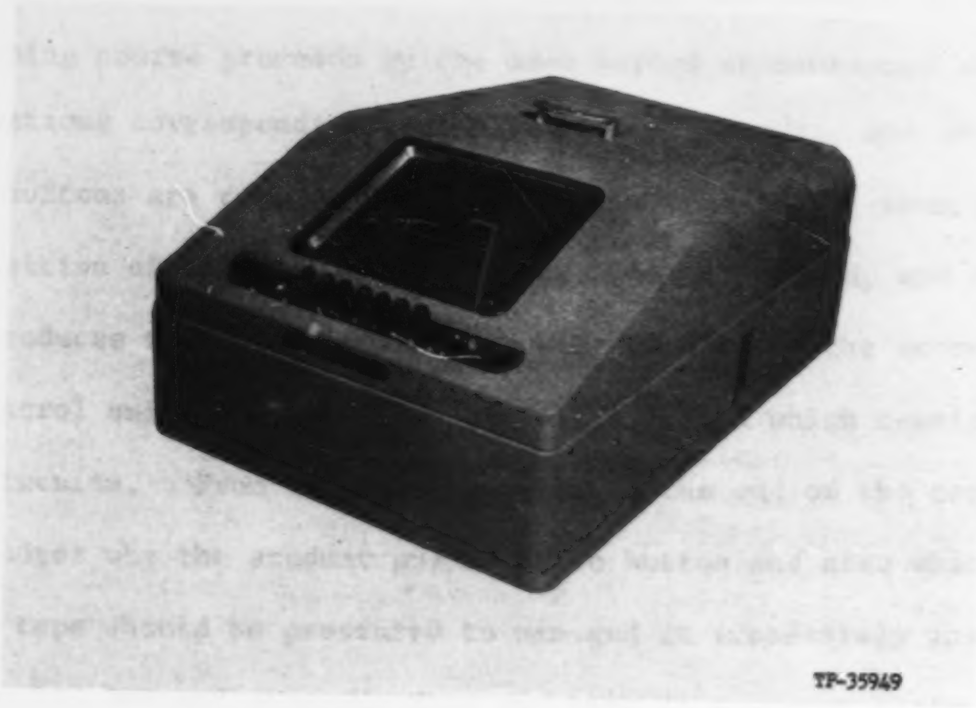

Figure 11. The display unit of the NEC-TMa teaching machine.

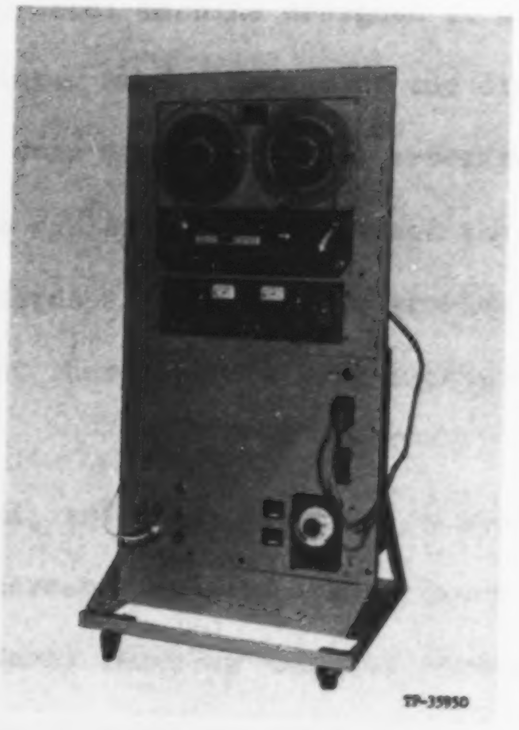

Figure 12. The control unit and magnetic tape recording system of the NEC-TMa teaching machine.

recorder to push a specific button. Then the next new problem is presented, and the teaching course proceeds by the same method as mentioned above.

Explanations corresponding to the problem and answer, and instructions for pushing buttons are recorded on the magnetic tape in the same sequence as the composition of the film to be projected on the screen, and the tape recorder reproduces them corresponding to what appears on the screen.

The control unit is a so-called artificial brain which consists of many logic circuits. From the first problem to the end of the teaching course, it judges why the student pushed which button and also what part of the film and tape should be presented to him and it immediately instructs the mechanism to move and stop the film and tape at a proper place. Moreover, the control unit consists of a device to measure the time required for the student to finish the course and an instrument to indicate the numbers of the correct and wrong answers which he gave.

NEC-TMb is a middle-level machine designed to display to a student the teaching materials by printed cards instead of the film for the foregoing high-class equipment and does not have a tape recording system.

On the NEC-TMc, the explanations to correct the judgment of students are printed on the same cards as that for the problem, and the machine is contrived so as to present them separately by incorporating an ingenious optical system.

Toshiba, Shiba Denki, and other electronics producing companies in Japan are becoming so interested in teaching machines that in a few years there will be many high-level teaching machines produced. With the advancement of the technical side of machines, more elaborate programs will be developed, not only in the field of school education but in the field of business and industry. Thus the future of teaching machines and programmed learning in Japan is bright.

CONFIDENTIAL PRE-COPY

PROGRAMED INSTRUCTION IN FRANCE

by

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In France individual researches have been often undertaken to improve the presentation of teaching, especially at the elementary school level. Programed instruction itself was introduced in 1959 and mentioned in different reviews. Here are the main articles chronologically listed:

-- "The Robot-Teachers Are Here," Lectures pour Tous, March 1961

-- "No Dunces for Teaching Machines," Science et Vie, May 1961

-- M. Rosenthal. "The Learning Machines," Revue Internationale de Filmologie, October-December 1961

-- S. Audebert. "The Teaching Machine, New Pedagogical Auxiliary," L'Education Nationale, December 7, 1961

-- E. Thil. "Revolution in Schools: The Teaching Machine," Constellation, September 1962

-- Martine Regnault. "The Learning Machines," Science et Avenir, November 1962

-- A. Ducrocq. "Machines and Intelligence," Atomes, December 1962

These articles quickly sum up the question and have been useful in making known programed instruction to a large number of people. During the same period, educators, psychologists, industrialists were questioning themselves, and today studies have been realized or are being realized now as far as both programs and machines are concerned.

1. The Programs

For programs, the most interesting researches up to now have been undertaken at the Centre d'études et de recherches psychotechniques (1). Mr. P. Coste, who is with the CERP, created some programs and experimented with them in different fields; the most important experiment was to build up a program in grammar of the Skinner type for an elementary course; the program had to teach the notion of subject and was divided into five lessons -- 150 frames -- plus two terminal tests of control. The objective of the experiment was to know what questions were not correctly answered by the children and why. It was also to examine the differences in results when the children can proceed at their own pace and when they can't. The last objective was to determine whether a second presentation of the program after some time could increase knowledge. The population was a class of twenty-six boys (seven years old as an average). The children were divided into two groups of the same level as far as intelligence and knowledge in grammar were concerned. The first one was working at its own pace, the second was working within limited time; the experiment, carried on during the regular classes, lasted three weeks and the final control test included questions taken from the program. During the experiment, the children appeared to be very interested, even when the frames were presented for the second time; they worked quite seriously and they concentrated more than usual. Questions taken from the program were introduced in the term paper and a very high percentage of correct responses was given; it is interesting to note that the very poor students gave only some correct answers, precisely those which were included in the program. The results showed a superiority of the children working at their own pace and also a definite improvement when they were going through the program for the second time. But the percentage of 95 per cent correct responses was never obtained, which is proof that some frames must necessarily be revised if a good program is to be built up, and that a second presentation cannot replace the revision.

Mr. Coste did further researches. He translated a part of the Holland-Skinner program in psychology and some experiments are now taking place with students from the Sorbonne. He is now experimenting with a 300-frame program of elementary statistics as well.

Mrs. Browaeys, who is with the CERP too, compared in 1962 the different types of programs according to the nature of learning. It concerned a course in electronics designed for technical trainees (two first months of training). The systematic analysis of all the work brought to light the most common mistakes. These investigations were completed by discussions with the trainees and instructors, and showed difficulties at different levels. Then Mrs. Browaeys classified the mistakes and chose the most typical -- in other words those which were due to unknown facts -- in order to write up the programed sheets to help the trainees. The programs were mainly of the Pressey type and the Crowder type (scrambled books). It was apparent that the first method gives better results with numerical calculation or pure memory; on the contrary when reasoning was necessary the Crowder type was more effective.

Mr. Le Xuan, who is connected with Unesco, pursued for a long time personal research on programed instruction; he recently finished a 500-frame program of design for high school students; this study was used on 600 pupils and is a part of a larger program of about 4000 frames.

Other studies have been conducted by the ORT Association -- Organisation - Reconstruction - Travail (2) -- founded in 1880 to encourage and develop industrial and agricultural work among the Jews in different countries. In France the ORT includes such centers as those in Paris, Montreuil, Strasbourg, Lyon, and Marseille,where training courses were given especially to young adults. Very soon this organization focused its attention on programed instruction. In June, July 1962, a seminar on this question was organized in Geneva with participants of different countries under the direction of the American professor, R. E. Silverman, chairman of the Department of Psychology at New York University, and an authority in programed instruction. The participants trained themselves to write small programs with which they experimented during the seminar, and decided to use the method in their respective countries. In France, a program in algebra for beginners was created by Mr. Gourevitch, a teacher at the ORT Center in Montreuil. At the same time, Mr. Bloch, of the Lyon Center, finished a program in electricity. A work session took place in June in Paris with Professor Silverman.

In the tenth issue of the review, L'Educateur, Freinet wrote about his "teaching box"; he made reference to his self-corrective cards, which help the student to do his work at his own pace and to correct himself; then he emphasized that his "teaching box" makes it possible to roll a printed sheet with the questions and corresponding answers. The lessons have to be oriented toward the difficulties which the students encounter most often. At the Freinet school, the use of these bands proves to be very effective; children are enthusiastic and their work is well done. When the problems are rather difficult, they are divided into simple questions which the child resolves one after the other thus arriving at a complete understanding of the question. These programed bands don't present all the characteristics of the usual programs, since it is more a question of the exercises than of the teaching itself; nevertheless they are useful and Freinet envisions their introduction into high schools and technical schools; they will facilitate the work of the students not only in calculus but in grammar and in geography.

2. The Teaching Machines

Mr. Barralon, an orientation counselor, has created a small teaching machine very handy especially for elementary classes. This device has two disks each of which can be turned to 12 different positions. To give his answer the student has to choose at the same time one of these positions for each disk; so he has one chance out of 144 to answer correctly, which does prevent a response due only to chance. The program is presented on a series of perforated cards and it is possible to proceed to the next question only when the combination of the disks gives the correct answer. The different possible responses are written on the disks: these can be figures (e.g., in calculus or in arithmetical problems) or words (e.g., in grammar or modern languages). When one goes from one series of questions to another one, he has only to change the programed cards and the circles of paper which fit on the disks.

Let us suppose that the child is troubled for a moment by a question he can't answer; the machine stops and he has to work out the solution -- if not, it is impossible to go further; thus the pupil will have to look at his multiplication table or at his grammar book; he will also be able to ask for explanations from his teacher or from his parents.

The cards can be programed for a simple test as in the example we have just seen but it is equally possible to build up the frames according to a logical progression, so as to help the child succeed; for example, a problem in arithmetic or in algebra can be broken down in small steps in such a way that the pupil can understand the mechanism of the whole question.

This very practical device allows the control of the progression of the students at any time; when the first mistake is made, they are immediately told so and they are prevented from continuing on an unsound basis; this is especially useful in complex exercises where a false start automatically leads to an incorrect final answer. It is impossible to cheat since the machine will not let the card free unless the correct answer is given. The machine has especially this advantage that it combines the method of constructed responses and multiple choice, for the child has to choose not one answer but two complementary elements which together constitute one answer and the number of possible choices is very high. It differs from the Pressey or Crowder type devices because the pupil first constructs his answer on scratch paper and then transmits his answer to the machine; thus the choice involves only a mechanical and secondary aspect and takes place only after the effective resolution of the problem.

Mr. Coste, whose experiments we have already mentioned, constructed a teaching machine of the Skinner type which allows for the running through of a program. In the "teaching box" of Freinet, frames and correct answers are written on a sheet of paper and presented successively to the student, but he has to write his response separately, not on the program itself.

In addition to these very simple devices, there is, at least in France, one machine of the adaptive type, the "Cybernex 124," worked out in collaboration with British specialists (3). Its outward appearance resembles a desk where the student, sitting in a normal working position, has before him a window which presents the successive frames of a program. Questions and answers are written on 60 large-size cards which are interchangeable.

The Cybernex is especially useful, for it allows all types of programing:

(1) Skinner-type program: When the student has written his response, he can compare it with the right answer.

(2) Branching multiple-choice program: After each question, the student has to choose among 4 responses by pushing a button in one of the 4 possible positions; a light indicates if the answer is correct or not and at the same time the machine compares the choice with the right answer and presents the following question or an easier intermediate step. If the student maneuvers the button into several successive positions, an incorrect answer is recorded. It is easy to program the course and to insert complementary steps.

(3) Branching with large multiple choice: The device can be equipped with 2 disks each holding 10 to 30 responses; the student makes his choice and the machine compares it with the right answer.

(4) Dynamic programing: The Cybernex can present the frames in a matter still more complex due to its memory function; the machine remembers all the mistakes and all the right

answers of the student from the beginning of the program; it can thus present the questions taking into consideration not the immediately preceding response but the average of all the results obtained before. If the student shows himself to be bright, the questions will become more difficult; if he is mediocre, they will be adapted to his level.

In a different realm, the "Cameca Company" (4) created a machine called "Scopitone" which, not being a teaching machine, would be able to play a pedagogical role; the Scopitone is presented as a type of juke-box with a normal size TV screen; the viewer can thus hear the song that he selects and at the same time see the rendition by the artist; the Scopitone includes a 16mm projector with 36 independent films and the length of each film runs about 4 minutes; it is possible to preselect the film that one wishes.

The Scopitone is not a teaching machine because it lacks a device allowing an answer to be given; however, one sees that it could be useful as a sort of reviewer presenting the most difficult points; students would have the possibility to come at certain times and in small groups to listen again to a certain presentation which was not understood immediately.

One can imagine that the film, after having transmitted the information, could ask the student for a question concerning what he has just seen; the student makes his response and the next film passes on, bringing the solution, explanations, and a new question.

3. The Organizations

At the research level, the organizations which concern themselves with pedagogical endeavors are necessarily interested in programed instruction. Thus it is necessary to mention above all the Institut Pédagogique National (5) and moreover the Centre Audio-visuel of the Ecole Normale Supérieure de Saint-Cloud (6) which has now the most complete documentation that can be found in France.

Recently an important organization has been created, the Association de Pédagogie Cybernétique with Mr. Louis Couffignal, General Inspector of Education, as chairman. The goal of this association is to insure permanent linking between specialists in all fields who are interested in the use of cybernetics in education. This Association is administered by a board whose members are necessarily connected with public teaching.

The Association publishes a tri-monthly bulletin called La Pédagogie Cybernétique (7), a journal of information and documentation concerned with the problems of research in the field. In the first issue, dated March 1963, Mr. Couffignal and Mr. Metais insist upon the linking of pedagogy and cybernetics. One of the main goals of the Association is to promote an effective teaching by the new methods; in this respect it must emphasize the validation of the programs, elaborate the criteria of effectiveness, and give eventually a stamp of quality in order to prevent commercial enterprises from selling programs or machines which offer no value.

In the framework of the Association, research is in progress on the elaboration of new techniques; the first work concerns the preperception and the prolonging of conventional teaching; it concerns knowing how the student can be prepared in the most effective manner to receive such teaching, how the environment and the means of mass communication can be utilized at the same time, before and after the lesson, in order to increase its effectiveness; the second operation consists of a systematic analysis of the question concerned, which is accompanied by the segmentation of knowledge. In the end, one analyses the psychophysiological processes of integration, in other words the different stages which allow the transformation of the information into knowledge. This research is well under progress, directed by Mr. Dubost and Mr. Metais, and up to now they have been concerned with the teaching of English (first level) and mathematics and French (first and second level).

In the commercial field, one important establishment is the Hachette Company which has been interested for some years in programed instruction and is involved in commercial relations with the American company, Encyclopedia Britannica Films. Mr. Barralon, whose name we mentioned already, is now in charge of developing a section of programing for Hachette; some EBF programs are under study to be adapted into French; a simple translation would not be sufficient because of the considerable differences which exist between the educational systems of the two countries.

An interesting experiment has already been carried out by a mathematics teacher, Mr. Lartigue; starting with the EBF course, he created three programs in arithmetic, geometry, and algebra for the ninth grade. His programs differ from the American ones in that the frames he built are rather long (half a page or more), and each of them generally includes more than one question. The students don't use any manual and they work at home on the program, each time running through a certain number of frames following the instruction of their teacher. In his class, Mr. Lartigue asks individual questions and explains more fully some parts of the lesson; all the students go frequently to the blackboard and the teacher can effectively evaluate each one of them while helping the weakest at the same time.

A new society has been recently created, the Didasco Company (8), which is devoted both to audiovisual methods and to programed instruction; this company, having contacts with American organizations, will adapt courses and will invite specialists from the United States to train programers. Didasco imports machines which it can rent or sell; it is ready to fulfill the demands of the customers in creating programs for the use of such an enterprise.

As an average, we can say that now many people in France are interested in programed instruction. An expression of evident interest can be found in the fact that a seminar was held at the Sorbonne in March 1963, under the direction of two well-known educators, Professor Oleron and Professor Debesse. Many people attended these meetings, hearing different lectures, mainly by Mr. Leplat, director of the CERP, the organization we have mentioned previously, Mr. Dieuzeide, director of educational TV, Mr. Guenot, professor at the Centre Audio-visuel, and Mrs. Leboutet, professor at the University of Caen. Since many people are learning more about this new type of teaching, and since many experiments are in view for next year, there is no doubt that there will be positive strides toward the use of this method at different levels.

People Active in the Field

Mr. Barralon	Orientation counselor, Librairie Hachette, 24 Bd. St. Michel, Paris 5
Mr. Biancheri	Philosophy professor, Ecole Normale Supérieure de Saint-Cloud, S & O
Mr. Bloch	Teacher at the ORT Center in Lyon
Mrs. Browaeys	Researcher at the CERP

Mr. Brunsvick	Chairman of the French Commission for Unesco
Mr. Canac	Assistant director of the Ecole Normale Supérieure de Saint-Cloud
Mr. Coste	Researcher at the CERP
Mr. Couffignal	General Inspector of Education, chairman of the Association de Pédagogie Cybernétique
Mr. Debesse	Pedagogy professor at the Sorbonne
Mr. Dieuzeide	Director of Educational TV
Mr. Dubost	Administrator of the Association de Pédagogie Cybernétique
Mr. Freinet	Editor of the educational review *L'Educateur*
Mr. Gourevitch	Teacher at the ORT Center in Montreuil
Mr. Guenot	Professor at the Centre Audio-visuel
Mr. Hignette	Executive, Librairie Hachette
Mr. Labin	Executive director of the Didasco Company
Mr. Lartigue	Mathematics teacher
Mr. Laurent	Agrégé de l'Université, English specialist
Mrs. Leboutet	Psychology professor, University of Caen
Mr. LeFranc	Director of the Centre Audio-visuel, of the Ecole Normale Supérieure de Saint-Cloud, S & O
Mr. Leplat	Director of the CERP
Mr. Lestage	Executive at Unesco
Mr. Le Xuan	Researcher at Unesco
Mr. Lillo	Researcher
Mr. Mathieu	Executive director of the Alba Company
Mr. Melamed	Executive at ORT
Mr. Metais	Editor of the *Bulletin de Pédagogie Cybernétique*
Mr. Mialaret	Psychology professor, University of Caen
Mr. Oleron	Psychology professor at the Sorbonne

REFERENCES

1 Center for Psychotechnical Studies and Researches,
13 rue Paul Chautard, Paris 15

2 Organization - Reconstruction - Work

3 Société Alba, 7 rue du Bois, Asnières, Seine.
Director: Mr. J. Mathieu

4 Compagnie d'Applications Mécaniques à l'Electronique, au
Cinéma et à l'Atomistique, 103 Bd. St. Denis, Courbevoie,
Seine

5 Mr. Dieuzeide, the director of educational TV, who is with this Institute, plans experimental research on programed TV.

6 The only French Center devoted to research, production, and teaching the audio-visual field; its director is Mr. Robert LeFranc.

7 Administration: Gauthier-Villars Company, 55 Quai des
Grands-Augustins, Paris 6

8 9 rue de l'Echelle, Paris 1. Director: Mr. Labin

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CYBERNETICS AND SOVIET PEDAGOGY

(The Application of the Knowledge of and Products Based on Cybernetics in Theory and Practice of Soviet Education)

by

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I

The scientific-technical-industrial revolution of the present time is being recognized, experienced, utilized, and pushed forward with a more remarkable awareness in the Soviet Union than in any other country (57). Even the difficulties which appear again and again and which are based mainly on the insufficient total planning are not misleading. A clear concept of future progress and planned projects provide the Communist Party of the Soviet Union (CPSU) with a new program which was voted for during the 22nd Party Day of the CPSU at the end of 1961 (55).

The central aims of this program are the "creating of the foundation of communism" and the "advancing of human society to the highest stage of development"; in other words, universal communism.

The main economic task consists of building up a technical-materialistic base for communism during the next two decades. This includes: the perfection of the technique, the technology, and the organization of collective production in all branches of political economy; the extensive mechanization and the more complete automatic control of the processes of production; the development of new, economical, and effective methods in all branches of production as well as the development of new kinds of energy and synthetic materials; and, in addition, a meshing of the theory with the practice, and an acceleration of the scientific-technical progress, including the necessary advancement of the techno-cultural level of the working people.

The explicit aim is to achieve and to guarantee an important advantage over, or a clear superiority over, the most developed capitalistic countries (55, pp. 143/44). This should be the most important goal at the present time and the near future, as well as the unalterable requirement underlying the hypothesized lawful determiners for the victory of communism all over the world.

A special and a fundamental importance is attached by the Soviet Party and State leaders to the development and improvement of science and general education (54; 55; 56; 57). The results of any one science, but especially of the natural sciences, and the application of these results in production or again in other scientific fields as well as in general education should serve the purposes of the main economic task and help to guarantee or to achieve the supremacy of the Soviet Union in these fields. Besides these, there are the following tasks for science which belong to the most important parts of the new program of the CPSU: the development of the theory and the principles for the production of new machines, automatic and tele-mechanical systems; the intensive development of radio-electronics; as well as the development of theoretical fundamentals and technical perfection of computers, regulators, and information machines (55, p. 270/71).

In the field of education in the Soviet Union (and therefore in all the other communistic educational systems) the main aim of the new program of the CPSU is the training and the education of the architect of communism -- a new kind of human being who is an all-round and a harmoniously developed personality, in whom spiritual richness, esthetical purity, and physical perfection are combined proportionately -- as has already been pointed out (55, p. 259).

Beside, or behind this general and rather idealized goal one can find in several authoritative documents more concrete and more realistic educational aims which have been stated very clearly and have been formulated already in Khrushchev's educational reform law (54; 58; 59), and which have been reaffirmed in the new program of the CPSU (55, pp. 252, 255, 260, 265, 268).

The "main principle of the design of education in moving toward universal communism" has been pointed out to be the absolute necessity for all students (their time for learning being continuously expanded) to gain practical experience in addition to their theoretical experience, and that all practitioners must study continuously in addition to their professional jobs (of which the time is more and more shortened). This is necessary in order to satisfy the continuously growing and changing requirements of production (54; p. 87; 55, p. 263; 56, pp. 16-18).

In order to satisfy these necessities, not only is a temporal increase required but also an intensifying, an updating, and an economizing of the educational system which can be achieved by the use of modern techniques, especially in the form of audio-visual teaching aids, instructional television (61; 62; 6; 41; 45) and newly designed teaching machines (obcajnscie masiny) (54, p. 101; 55, p. 267; further 60; 61; 62; 6; 41; 45).

II

In 1954 (!) one could still find under the term "cybernetics" in the Soviet philosophical dictionary, which is the compulsory and official language code: " . . . is a reactionary pseudo-science which was developed in the U.S.A. after World War II and which was also widely disseminated in other capitalistic countries. It is a form of modern mechanization, . . . by which the qualitative aspects of the principles governing the different forms of life and by which the development of matter is denied. . . . By its nature, cybernetics is directed against the materialistic dialectic, against the modern concept of physiology expounded by I. P. Pavlov, as well as against the new Marxist and scientific interpretation of the laws of life of the society. Cybernetics vividly illustrates one of the characteristics of the ideology of the bourgeoisie, that is, its inhumanity. It endeavors to change the working people into a part of the machine; into an instrument of production; into a weapon of war" (52, pp. 236/237).

In contrast to the above definition, one can find nowadays: "Cybernetics and the methods of cybernetics designed by men organize the most complicated processes which appear in the organic and inorganic world, and analyze the large stream of information (a process, if done by hand or by the ordinary machine techniques, is unthinkable), and therefore makes it possible to discover all the new peculiarities of natural phenomena and to speed up the development of physics, chemistry, biology, and the other natural sciences. . . .

"The methods of cybernetics can be used for setting up designs which specify the variables to be investigated and under what conditions, in other words, designs which will lead to the best of all possible results.

"Cybernetics can also be used for the control of complicated processes in production; it takes into account the processes of the work itself, it points out errors which arise, and it chooses the best working tempo. . . . All this contributes to the expediting of the development and the attainment of a greater economy in the production of materials and, in this connection, it relieves man of many routine processes and makes his work more creative.

" . . . Not only the successful application of cybernetics, but also progressive automation in the field of production lead us to expect that all functions in the process of the production of materials which are being performed by men will change basically.

"There are already in existence self-regulating systems. All that man has to do is feed into the system a program which, in turn, determines the activity of the system. Obviously, an era has begun in which man will be almost completely free of any physical labor and his only function will be to install and switch on the instruments of production. Such changes in the use of the instruments of production in a communistic society will lead ultimately to a harmonious integration of the intellectual and the corporeal in man's production activities." (57, p. 50, 51)

The period of time between the publication of these two diametrically opposed statements of the importance and the value of cybernetics was characterized by a change in thinking which one can follow in the Soviet technical literature (see below a representative selection) dealing with the problems of cybernetics (mostly philosophical problems or questions).

Following a certain introduction in 1955 (24), a serious discussion was held in 1957 (2; 8). In 1958/59, in addition to some of the Soviet-Russian papers (3; 42) the translations of the studies of Norbert Wiener (15) and W. Ross Ashby (51; 50) were published. In 1960 and 1961 the first Soviet-Russian monographs concerning the problems of cybernetics and the application of cybernetics to other (natural) scientific fields were published (32; 38; 46), as were numerous articles on the philosophical questions of cybernetics (11; 36; 25; 14; 22) as well as its application to the natural (30; 35) and social (behavioral) sciences (1; 9; 63; 64).

The studies published in 1962 and in the beginning of 1963 (i.e., 12; 13; 37; 57; 49) show clearly that the Soviet Party and State leaders have accepted the results of the Soviet science and have attached the highest value to cybernetics and its universal application to the different fields of science, economics, and culture. The Party and its leaders have taken appropriate actions, or rather made suitable preparation for the necessary research to be done in this field and the immediate application of the results to all the other fields. The stage of especially the philosophical penetration into the questions of cybernetics, mainly its application to human beings (in physiology, medicine, psychology, education, jurisprudence, etc.), was reflected in the Theoretical Conference of the Philosophical Seminars on the Philosophical Questions of Cybernetics in Moscow (13, pp. 146-153) on June 1 and June 2, 1962, as well as in the resolution of this conference (37, pp. 153/54).

III

The Soviet educational reform law and the new program of the CPSU of 1961 asked for the extensive use of modern technology, especially film, tape recordings, television, and also the products of cybernetics, in educational practice and research (54; 59; 55; 61).

However, it was not until 1962 that the questions concerning the use of cybernetics, including statistical methods and teaching machines, were discussed in more detail in the Soviet literature, especially by V. A. Artemov (4), P. R. Atutor (7), L. B. Itel'son (20; 21), L. N. Landa (27; 28; 29), M. I. Rozenberg (39), and E. E. Solov'eva (43). These studies give a good overview of the present Soviet interpretation of the use of cybernetics in educational practice and research. Furthermore, it must be pointed out that the term _cybernetics_ as used in the Soviet literature does not mean only the finding of algorithms but also the utilization of other mathematical methods, electronic computers, and also teaching machines (7, p. 147).

The application of mathematical methods and devices of cybernetics afford opportunities to examine statistical laws and processes and to explain them in mathematical terms which indicate the tendency toward development. This allows the descriptive methods used in some scientific disciplines to be replaced by the more exact experimental and mathematical methods (4).

The understanding of the principles of education and the laws of nature may be inconsistent with their application -- this, at least, is the concept underlying Soviet pedagogy (4; 7; 18; 21; 28; 39; 43). The empirical-practical cognition which in part will determine the principles and methods of instruction and education has to be differentiated from the scientific cognition of the educational processes. The scientific cognition can be more effectively utilized in formulating educational principles than can the empirical-practical cognition (7).

The development of (Soviet) pedagogy has many characteristics in common with the development of the natural sciences which one can easily differentiate as the phases of description, of qualitative analysis, and, at last, of quantitative analysis. In order to progress on to the phase of quantitative analysis in the field of pedagogy (as well as in any other science) it is necessary to achieve a high level of qualitative analysis and a clear concept of the nature of the research objects. Cybernetics can play an important role in the advancement of pedagogy toward a newer and higher scientific level. This possibility results from the nature of cybernetics and its utility in examining the complicated processes and phenomena which appear in living nature, in human society, and in production, and, therefore, in achieving the stated aims in the most profitable way (7).

From the Soviet point of view the achievements of cybernetics and the methods of cybernetics can be used: first, for the automatic collecting and processing of the pedagogical information; second, for gaining the most logical structure for the teaching situation by examining the effective principles of teaching machines. In the opinion of A. I. Berg (10), a member of the Academy of Sciences of the Soviet Union and one of the leading Soviet scientists in the field of cybernetics, our knowledge of instruction and self-instruction gained through the use of teaching machines requires us to change our attitudes concerning the educational processes. There is no doubt that there has been essentially no development in the field of education for hundreds of years (!) in contrast to development in other scientific fields or in the dynamics of the society and nature; third, for examining the educational process itself; fourth, for determining the extent and the content of education required by the development of the society, of science, and of production; fifth, for the scientific planning and distributing of educational institutions throughout the country, resulting in a network of schools.

The difficulty in applying cybernetics and the methods of cybernetics to pedagogy is due to the fact that the cybernetic machines need to be programed in the form of (mathematical) formulas. But many processes and phenomena in education and especially in instruction cannot yet be formulated in mathematical terms, even if some important work has already been done (4; 20; 21; 39; 27; 28; 29; 43; 18; 26; 41; 45).

Even if we apply the results and methods of cybernetics to pedagogy, there will be the additional question as to the capabilities of the cybernetic machine itself: can it carry out all functions which are not built into it by the constructor? (7). The results of the latest research give a positive answer to this question: it is sufficient that the constructor equip the system with a much more general characteristic, which is the ability of the system to correct its own errors and to learn, and to build into the system general criteria by which it can evaluate the results of its work. If the automatic machine has these abilities, it will work out the best structure for the system and an appropriate law of behavior which, as a matter of fact, in many cases will surprise the constructor himself. Therefore, one can expect, with a high degree of certainty, that such systems which will be constructed automatically expand and improve on their structures which reminds us of the development of living forms, in a certain way (44, p. 40). From the Soviet point of view, one can certainly expect that the study of such systems will contribute to the determination of the most effective and logical structure of the educational process and to disclose its principles.

IV

The Soviet-Russian slogan "catch up to and surpass the United States," which, as a motive, can not be estimated high enough for the techno-scientific efforts of the Soviet Union, applies also to the technological efforts (as modernization) in education. Besides instructional television there are also the new teaching machines (obucajuscie masiny semantically and grammatically adequate as a translation of teaching machines) which, after being developed and tested in the United States -- developed by S. L. Pressey in the twenties (78; 79) -- were examined for their applicability to the Soviet educational system by Soviet pedagogues and have already been used in an initial test series.

Besides the above-mentioned development of cybernetics and the techniques of cybernetics, the visit and the lectures given by Prof. B. F. Skinner of Harvard University in Moscow and Kiev in 1961 were important in initiating the Soviet-Russian studies in this field. Credit can be given to Professor Skinner for familiarizing the Soviet pedagogues with the problems of programed instruction (programmirovannoe obuconie), the use and construction of teaching machines, as well as the various problem-solving experiments.

It is true that Professor Skinner's ideas (see the first rejection of cybernetics in the Soviet Union (52) !) were at first viewed with some reservations (16), but soon after his visit in 1961, more detailed studies were done in the United States in the field of programed instruction as well as in the construction and application of teaching machines (33; 40; 48). In 1962 some Soviet studies in this field were published (5; 6; 7; 10; 17; 18; 26; 28; 34; 39; 41; 45).

Besides the studies by B. F. Skinner (66; 80; 81), the work done by the following men, which have been cited in reference (48) as contributions to the development of this field in the U.S.A., were taken as a basis for the Soviet-Russian studies: Whitemore (67), Louchren (68), Macgovern (69), Williams (70), Cron (71), Smalwood (72), Ley (73), Bitzer (74; 75), Bushnell (76), and Quakenbush (77). There are three reasons for the intensive study and experimentation done in this field in the United States: first, the rapidly developing crisis within the educational system in the U.S.A. This crisis seems to have been initiated by the rapidly increasing number of students with an equally rapidly decreasing number of qualified teachers (the qualified teacher would move on to much better-paid jobs or positions in industry); second, the recognition of the need for improvement in the quality of general and vocational education (this need for improvement is evaluated as the last struggle before the inevitable end of capitalism!); third, the endeavor by private industry to obtain greater profits (40; 48). However, these reasons do not restrain the Soviet pedagogues from seriously considering the results of the studies done in the United States in this field and applying these results to their own educational system.

The ideas and principles of programed instruction and the construction and use of teaching machines are considered useful in the Soviet educational system or at least worth discussing. However, programed instruction with teaching machines should be combined with the usual form of instruction as well as with instructional television. Furthermore, it has been stated that programed instruction and teaching machines are basically possible and are recommended for use in all disciplines within and at all stages of the educational system with adequately differentiated programing.

However, all those in the Soviet Union working in this field do not yet agree completely with the opinion, especially Skinner's opinion, that instruction by the use of teaching machines is more beneficial than the usual classroom instruction and that it can be considered as a kind of private teacher for each student (66; 40; 48). Programed instruction cannot be considered by the Soviet pedagogues as necessarily more beneficial because they advocate the principle of collective instruction. On the other hand, the Soviet pedagogues accept the possibility that, in principle, mass instruction can be achieved by using teaching machines. A most qualified specialist who works as a programmer can design a program which is appropriate to the teaching of an unlimited number of students.

The Soviet reporters criticize especially the state of development and use of teaching machines in the U.S.A. because the American studies and experiments show a too low level of generalization, and the question -- which is more important for the Soviet circumstances -- "how does the price of programed instruction per single pupil compare with the price of the usual instruction using textbooks, etc.," has not been asked and, therefore, has not been answered but has simply been taken for granted that the costs of both forms of instruction are nearly the same. These objections result from the fact that textbooks are relatively cheap in the Soviet Union, but adequate teaching machines are, on the whole, more expensive to produce than in the United States.

Based on the results of the American experiments the Soviet pedagogues (16; 33; 40; 48) are in general agreement that: first, programed instruction can and must be used more and more in the Soviet Union in the future; second, many studies and experiments have to be done on a broader scale (in order to make sufficient generalizations); third, the use of relatively simple mechanical and electro-mechanical teaching machines is less effective because these kinds of machines are little better than the usual form of instruction;

fourth, the use of the most simple machine, of the "repeater" type, can be successfully used both in initial learning and in prolonging retention of already learned material; but fifth, teaching machines developed on the basis of electronic high-speed computers can be more successfully used in promoting retention of learned material and skills in the various branches and at the various stages of the educational system.

V

A very important, probably the strongest, motive for the development of educational cybernetics in Soviet science arose out of the realization that the rapid development of the sciences and the technologies has created a disparity between the volume of knowledge so far collected and man's assimilation of it, and this disparity was steadily increasing. It will become more and more difficult to eradicate this disparity because of the fact that man has a limited ability to remember and also a limited time to devote to learning, both of which cannot be developed much further. Even now, the time required for learning is nearly equal to the time man spends in learning and working.

Faced with this situation, the only recourse left is to increase the amount of information learned or assimilated (which is now reduced and selected) by modernizing the teaching processes and especially the conditions for learning. The efforts made to increase production capacity which have played an extremely important part in the fulfillment of economic plans, should now be carried over into the field of education. The Soviet pedagogues, who have always kept in mind the general improvement of their country, have clearly recognized that a minimal increase in their achievements in education will, without doubt, also have a beneficial effect on all other fields such as economics, technology, and science (45). More and more, the Soviet pedagogues are accepting the idea that especially the process of instruction can and has to be considerably changed by using modern theories and methods of logic, mathematics, and cybernetics, and by using adequately constructed technical media (28).

In order to modernize the educational processes, it is first of all necessary to analyze in detail the process of instruction in view of cybernetics, that is, in terms of communication, information, and control. Since the psychical processes the student goes through are steerable (controllable) as are the physical, chemical, biological, and other processes (27; 28; 29), the problem which has to be solved is one of finding the laws of this control and controlling completely these laws. Therefore, pedagogy has taken on some aspects of cybernetics and can be based in part on the results of cybernetics. An analysis of the processes of instruction based on the principles of control and the requirements which have to be satisfied for a "well-controlled system" will disclose a series of errors in the present theory and practice, but at the same time, it will also disclose methods for overcoming these errors. Such an analysis allows especially the formulation of some requirements for programed instruction which are very necessary for the successful presentation and accomplishment of instruction.

The programing of instruction may not only be confined to the design of the program of a subject, in other words, what should be learned, but also it has to include the programing of processes by which the information can be transmitted and learned, that is, the teaching and learning processes, or how a subject should be taught and learned.

The core of the thinking of some Soviet pedagogues and psychologists (concerning cybernetics) is the relationship between "operational formation" (*pooperacionnoe formirovanie*) and "operational control" (*pooperacionnyj kontrol*) of the psychical processes of the students during the period of instruction (the learning situation).

In the opinion of these Soviet pedagogues and psychologists the most important task of the Soviet pedagogical science (concerning the *what* and the *how*) is to discover such methods and forms of organization of instruction which guarantee an absolute and reliable operational formation and control of the psychical processes of the learning students for whom the operational control is an important condition for the success of the operational formation of the psychical processes.

The success of the operational control, i.e., the control during the exercise of the individual elements of an action (the "operations"), however, presumes that the instruction will be a "process with reliable feedback" (*process s cnorosej obratnoj svjazljn*). In order that the teacher will be able to identify and to eliminate in due time all deviations which arise during the instruction, he needs constant and sufficient information about what is going on in the consciousness of the student as he acquires certain knowledge, as he solves problems, or as he accomplishes actions. Without such information, an extensive, if not complete, control of the processes in the consciousness of the students is not possible.

A principal failure in instruction at the present time (inside as well as outside of the Soviet Union) centers around the fact that the usual methods of instruction are "methods which provide poor feedback." Usually, the teacher does not know whether the information presented is being taken in consciously by the student and whether this information is being assimilated in a manner which is not only expected but which is also necessary. If the teacher does not have this feedback he can not adequately control his actions in relationship to the progress the students are making in learning the subject. This means that the instructional influences of the teacher oftentimes are not adequate for the reality of the situation and, therefore, that his instructional influences are greatly ineffective, if not even obstructive.

The teaching machines are able to eliminate or avoid this problem. The most important difference between the teaching machines and other technical teaching aids consists precisely in the fact that teaching machines can give "immediate feedback" to the teacher concerning the learner. Only teaching machines can be said to be the technical devices which can perform this most important function of the teacher -- the function of the "inverse influence" on the students, the function of controlling the student's actions and learning processes by a certain (retrospective) reaction to these (28, p. 86).

In the opinion of the Soviet experts (who, in this case, are in complete agreement with the majority of the American experts in this field) it will be possible through the use of teaching machines (which guarantee a successful feedback) to increase considerably the learning activity and especially the learning successes of the student, to enhance the interest in and increase the intensity of self-learning, to design the instruction according to the individual characteristics of each student (thus to individualize the instruction) as well as to shorten the required time for learning and at the same time to enlarge the volume of materials to be learned.

Nevertheless, there will still be a need for a teacher in the field of instruction but his function will be changed; namely, he will be relieved of such tasks which do not require special qualifications. Now, guiding the processes of rote learning takes much of his time and energy and gives him only a limited opportunity to accomplish the necessary "precision work" with the students which is so important for the development of their personalities and the development of their capabilities and talents. The teacher will still lead the instruction, but the importance of his role will be elevated. He will have to solve complicated methodological problems, he will have to go deeper into the psychology of teaching and the psychology of learning, and he must be able to analyze the reasons underlying difficulties which individual students might have in their assimilation of materials.

In order to accomplish these aims, it will be necessary to change the training of as well as to provide further education for teachers. These requirements do not only belong to the training of future teachers but also to presently active teachers. They must become familiar with the operation and the use of teaching machines as well as have a general knowledge of the field of programed instruction and its principles.

VI

In a paper published by the Ministry for Education at Universities and Professional Schools of the Soviet Union in the fall of 1962, it was pointed out very strongly and with astonishing clarity that it is necessary to use individual learning methods which are more effective than the usual collective learning methods. Also the Ministry asked that programed instruction with the optimal control of the learning process be used in the Soviet universities and professional schools (34, p. 89).

In view of this the following scientific tasks have been considered to be of immediate importance: research on the principles of perception; an examination of the learning and remembering of external information by human beings; the development of an effective quantitative (logical and mathematical) theory of instruction; a fundamental revision of the content of subject-matter (of knowledge and skills) and the compilation of logical instruction programs (teaching plans) for subject-matter; the development of cybernetic teaching machines and the adoption of universal computers for mass use as individual teaching machines; the development of complex systems for programed instruction and the development of designs for the technical-organizational reform of educational administration in the universities and professional schools and a complete experimental revision of these systems in research universities and professional schools; and the training or re-education of the lecturers at the universities and professional schools concerning the new requirements and methods in the use of programed instruction. These tasks should not be confined to daytime classes, but should be extended to evening classes, and, especially, to correspondence courses.

In answer to a stimulating article (6) in the August 1962 issue of the College Messenger (Vestnik vyssej skoly) as well as in reference to the above-mentioned suggestions of the competent ministry, (34) a series of articles were published in the January 1963 issue of the same journal of the Ministry for Education at Universities and Professional Schools of the Soviet Union in which there was a discussion of the present state of development of programed instruction and the design and use of teaching machines in Soviet universities (17; 18; 26; 41). These papers written during the second half of 1962 and the first half of 1963 (i.e., 5; 7; 20; 39; 40; 43; 45) point out that the preconsiderations and principal decisions of the mathematical, the technical, and the anthropological-educational phases have been worked through and that now the phase of concrete considerations and experiments has started. This latter phase particularly applies to the technical colleges, but in part also to other kinds of universities and professional schools as well as to a very limited number of public schools. Therefore it is not astonishing that the technical colleges have excelled in the development and that the current reports on concrete experiments come from educational institutions for engineering because these institutions have the best conditions in which to develop such studies.

Having established the need to modernize and intensify the learning process by the use of programed instruction especially in universities and professional schools, an attempt will now be made to clarify the structure of programed instruction by distinguishing between teaching algorithms and teaching machines.

The subject of a certain curriculum will be divided into "portions" and will be presented in doses to the student. After the student has learned each "portion," he performs some task and then gets a response of his output. In order to be utilized in such a way the material to be learned has to be combined with a teaching algorithm which provides for, first, an analysis of the whole curriculum to be presented and a division of the whole into logical "portions" and second, a logical sequence of presentation of these "portions" which will allow the subject to be learned as quickly and effectively as possible. Such a teaching algorithm has to be in a logical relation with the subordinate teaching operations (which are in the service of the teaching algorithm) and also in a logical relation with superordinate teaching operations (to which the teaching algorithm itself is in service), or rather to take into account and to disclose the relations.

Programed instruction, consequently instruction according to teaching algorithms, affords the opportunity to use teaching machines as the media of automating the process of instruction which guarantees feedback between the student and the lecturer. The instructor, or rather the teaching machine itself, reacts to the behavior of the student while he is learning a subject and, therefore, is able to control the learning process systematically. Furthermore, statistical data can be gathered by the teaching machine which registers the behavior of the student. By analyzing these statistical data further, questions concerning the learning process can be formulated and solved.

VII

The teaching machine (the automatic device) is -- by a definition given by A. I. Fel'dbaum (13, p. 147) -- "a system whose algorithm changes its aiming device automatically and this algorithm has not been installed by the constructor."

There are three ways to elaborate on systems of automatic teaching: the mathematical, the psychological, and the physiological methods. By using the mathematical method the problem of constructing a teaching device will be formulated and also solved in mathematical terms. Considerable success has been achieved by using this method (in the opinion of B. V. Birjukovs -- 13, p. 147).

However, in more complicated cases, the use of mathematics will be difficult and to some extent impossible. Then one has to study the human being and to try to copy the processes of teaching as well as of learning. In the learning process searching (and experiencing) plays an important role. Now the constructors of new automatic devices oftentimes allow for algorithms which provide for searching. This method is known as the psychological method. The psychological method, in turn, finds its completion in the physiological method which is analogous to the methods used in training animals and the construction of automatic teaching devices is based on these methods.

Furthermore, the teaching machines can be distinguished by the form of construction, by the principle of instruction, and by the kind of feedback. By the form of construction one can distinguish electronic dialing machines; (modeling-) machines which work on the principle of analogy; portable electro-mechanical teaching machines; and, last, portable electronic teaching machines. By the kind of feedback (i.e., by the input device) one can differentiate teaching machines with the choice-input of data, with the number-input of data, and with the result-input of data. Finally, there are individual-group- and conveyor-belt teaching machines subdivided according to the principle of instruction (41, p. 15).

If such teaching machines and programed instruction are used, it is necessary to establish quantitative parameters which are capable of being tested and retested and which characterize the two main factors being affected, namely, the learner and the teacher, from the point of view of their dynamic characteristics in the control system. These parameters have to be supplied by experimental pedagogy, psychology, and physiology. The instruction has to be constructed in such a way that the dynamic characteristics of the teacher as well as the learner will be taken into account.

Furthermore, the communication channels and especially the effectiveness of the feedback will be improved as the cybernetic teaching machines inform the teacher of how the student is learning the given material. The verification of the actual results of the instruction has to be connected in parallel to the performance because the teacher is only able to check the results of learning the material if he compares the student's activity with the activity of a human being who is a master of the subject-matter, who is able to use his knowledge in solving typical problems and who has a certain amount of skill. Therefore, it is necessary to introduce quantitative parameters which characterize the quality of knowledge, abilities, and skills which the learner has to identify in the verification of that which he has learned (18, p. 20).

A further requirement is the maximal individualization of instruction which -- as mentioned above -- appears remarkable in view of the fact that so far exclusively collective instruction and education has been demanded. However, the individualizing of the learning process is considered in a dialectic connection with the collective teaching methods. That is, the requirement for the individualizing of instruction is closely connected with the requirement to guarantee the individualized process (especially the learning process) within the collective instruction; even more "to extend this to a mass phenomenon." But this is only possible with the aid of teaching machines.

Finally, the application of cybernetic methods and machines in instruction requires that the teacher is not only an expert in his field, especially in its logical construction, but also that he knows the particular operations which the learner has to accomplish in learning the subject. Thus, the teacher has to be acquainted with all the characteristics of the instructional process as well as the optimal methods.

VIII

The theoretical considerations and the first practical experiments using teaching machines were directed toward the transmission of knowledge in the field of mathematics (including physics and technology) and in the teaching of foreign languages. This can be explained by the fact that the teaching machines were developed by (mathematically trained) representatives of the technologies (5; 26; 41; 45) and -- what seems to be important for foreign language teaching -- by the fact that one of the most extensively developed fields in applied cybernetics in the Soviet Union is the mechanical translation from one language to another (63; 64).

In addition to this, teaching foreign languages is not only compulsory in the public schools but also in the universities and professional schools. For this reason, there exists a high degree of interest in the Soviet universities and professional schools and in public schools (also among the representatives of the technologies) in constructing adequate machines for teaching foreign languages which can release the student from the predominant and unpleasant task of "learning by heart" the words and rules of the foreign language. The greatest amount of time in teaching foreign languages -- so the Soviets argue further -- is devoted to practicing words and rules. Through the construction of a translating machine (which may be as small as a cigar box) which includes a minimum vocabulary (i.e., the most common and most used words and idioms) and which presents the appropriate term in the mother tongue visually or acoustically, foreign languages can be taught much easier and more rapidly. Technically, it is possible to construct such a machine -- the size of a portable transistor radio -- which can even present the grammatical rules of the respective foreign language.

In the opinion of V. A. Artemov (5), cybernetic machines (in technical combination with other audio-visual media) can be used for the following specific tasks in foreign language teaching: first, for the presentation of perfect pronunciation of the foreign language by the teacher who is a native speaker of that language; second, for the recording and the reproduction of the repeated efforts of the student; third, for the showing (on a projection screen) of a spectrograph or a graph of intonation of the pronunciation of sound in isolation or sound combinations (words, sentences); fourth, the showing (on a projection screen) of spectrographs of repeated efforts of the student (whereby also the respective spectrograph of the perfect pronunciation of the speaker will be shown for comparison); fifth, the transmission of the vibrations of sound produced by the teacher or speaker to a power unit through which the student can feel these vibrations with his hand; sixth, the transmission of the vibrations of the sound produced by the student to another power unit through which the student can feel his own sound vibrations (with the other hand) so that he can compare it with those of the teacher or speaker.

Therefore, a very intensive and individual learning of the foreign language will be possible whereby the teacher can concentrate on an immediate control and elimination of students' mistakes. This presumes, however, that such a foreign-language-teaching-machine, a kind of "cybernetic combine" (kiberneticeskij kombajn -- 5, p. 82) has an immediate feedback from the student to the teacher.

IX

Even though there has existed (for a short time) a complete awareness of the possibility of as well as the necessity for the development and use of teaching machines in the Soviet Union, the techno-practical realization has not been achieved but this will probably change (in its limits) during the next few months.

From December 11 to December 13, 1962, the "Scientific-Theoretical Conference on the Questions of Programed Instruction and the Use of Teaching Machines in the Instruction Process" was held at the Radio-Technical Engineering College in Kiev (17). More than three hundred representatives, pedagogues, psychologists, mathematicians, cyberneticians, radio-technicians, and linguists, from 105 universities located throughout the Soviet Union participated in this conference. This conference can be considered as the first big meeting held in this special field in the Soviet Union. About twenty models of general and very simple teaching machines (automatic devices) which have been developed especially by the host University of Kiev as well as the Moscow Energetic Institute (Moskovskij Energeticeskij Institut) were shown. However, at the present time there are actually only three types of teaching machines which are known or rather have already been used in the Soviet Union outside of the places of their development for experiments in programed instruction with teaching machines.

The first type of teaching machine which has become known in the Soviet Union can be considered to be the "Repeater I" which was shown by L. N. Landa (Institute for Theory and History of Pedagogy of the Academy of the Educational Sciences of the RSFSR in Moscow -- 27; 28; 29) at the Third All-Union Conference of the Use of Technical Teaching Aids in Education which was held in Moscow in June, 1962 (45). With the aid of this teaching machine the student should be able to learn to analyze complicated sentences step by step. The teaching machine registers the mistakes made by the student and evaluates the work carried out. This teaching machine can not only be used in teaching the mother tongue but also in teaching foreign languages and mathematics.

To the knowledge of the author, the second machine to become known was "Examenator (I)", a cybernetic model which was developed and tested (probably by Ju. N. Kuselev and M. V. Gumileva), at the Moscow Energetic Institute in 1961/62 (26; 45). This automatic device should serve in the experiments on automatic control of the learning processes of the students at the Energetic Institute. This automatic device was constructed by the students of this university under the direction of the above-mentioned scientists. These students are members of the "student construction office."

A simple control-algorithm was selected: the student (as the subject) was given a series of questions concerning the material to be learned and for each question there were different answers (on the average three: one right and two wrong); therefore, each student had to choose the correct answer from among the three answers. The "Examenator" registered the number of correct answers as well as estimated the time which was necessary in answering the questions. The structure and the function of this type of machine are described more clearly in the article by Ju. N. Kuselev (26).

The third known Soviet teaching machine is the "Ural I" which was developed at the Radio-Technical Engineering College of Kiev (probably by Ju. P. Gorjunov) (41). This machine was especially developed for the experimental retesting of the algorithms for the programed-university-instruction. These algorithms were also developed at that college.

In fact, with this machine the possibility of using electronic computers as teaching machines was proved, in principle, even though the machine turned out a series of mistakes. Thus, for instance, the individual use of teaching machines was a failure in a big group. Primarily, the necessary algorithms were missing and, furthermore, the "Ural I" made such a loud noise that it could not be used for a group of twenty or thirty students in a classroom at the same time because the noise level could not be tolerated.

In summarizing the state of development of programed instruction and the construction and use of teaching machines in the Soviet Union, one gets the following picture: The mathematical-cybernetic, the physical-technical, and the anthropological-educational stipulations for a broader development and a rapid progress in this field can be considered as dominant. On the contrary, a considerable backwardness -- the backwardness in their own theoretical ground work as well as in contrast to the industrial development in the United States -- exists in the development, construction, and testing of concrete types of practical teaching machines for programed instruction.

Teaching algorithms are being developed rapidly and with constant enlargement and differentiation of scope, but mainly in teaching at the technical universities.

But, since the development in this field is considered as a special condition for increasing the effectiveness of the educational system -- which, in turn, is basic to economic successes and, therefore, to the aspired final victory of communism over the capitalistic world (54; 55; 56; 57; 58; 59; 60; 61) -- it can be expected that in the near future, probably even in the next few months, this picture will be changed in favor of the Soviet Union.

In any case, it is certain that -- next to the United States -- the Soviet Union has achieved greater development in this field than the rest of the world, including West Europe and the Federal Republic of Germany. The importance of this development can not be underrated since the Soviet Union endeavors to continue experimenting in this field in order to "catch up with and surpass the U.S.A."

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